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CALORIC:

ITS

MECHANICAL, CHEMICAL AND VITAL AGENCIES

IN THE

PHENOMENA OF NATURE.

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CHAPTER I.

INFLUENCE OF CLIMATE AND SEASON ON THE PHYSICAL, INTELLECTUAL AND MORAL CHARACTER OF THE HUMAN RACE, AS SHOWN BY THE DIFFERENCE OF STATURE, MAGNITUDE OF THE CHEST, CONFIGURATION OF THE BRAIN, COMPLEXION, ETC. AMONG THE VARIOUS NATIONS OF THE EARTH.

"If ever the science of life, and with it some of the most important departments of human knowledge, be destined to make any decided progress toward perfection, it must be by the road of experience, aided and enlightened by general philosophy."—LAWRENCE.

"Give me the geography of a people, and I will give you its history."—COUSIN.

NEXT to the discovery and development of some grand truth capable of universal application to the benefit of mankind, the most important service that an author could bestow upon his species, would be to select from the vast accumulation of fabulous and contradictory statements that compose the mass of our printed books, whatever is really valuable. For, at

present, the elements of knowledge are scattered over so broad a field,—many of them are so imperfectly defined, and the truths already discovered are mingled with such a multitude of errors, that the best portion of life is spent in learning how little is known with absolute certainty. But the time is not distant, when an unity and precision will be given to science, by a luminous arrangement of all its branches and their reduction to the simplicity of established principles, that will render its acquisition as delightful and rapid, compared with its former progress, as are the present means of locomotion by steam power, contrasted with the slow and laborious methods of travelling before that mighty engine of civilization was invented.

When it shall be fully understood, that the true method of exploring the head-springs of science, and of resolving the most difficult problems of nature, is to observe accurately, and record faithfully, all her proceedings, innumerable obscurities will vanish, like mists before the mid-day sun. And there is reason to believe that the partial success of philosophers has been owing to their having attempted too little rather than too much. For if it be true, that all the operations of nature are connected together as one harmonious system, it is obvious that no one of them can be rightly understood without a general acquaintance with the whole:—

> "The only hopes forever doom'd to know
> A false event, are those that aim too low."

And if it be true that caloric is the primary physical cause of all the mechanical, chemical and vital

changes of matter, it follows, that every diversity of organized bodies must be immediately connected with the agency of external temperature.

Perhaps there is not a greater contrast between the plants and animals of different planets than between those of the tropical, middle and polar latitudes of the earth. We have already seen, that the number of volcanos, the elevation of mountains and plains, the amount of evaporation and rain, the magnitude of rivers, and the strength of vegetation, are in proportion to the heating power of the sun. Nor can there be a rational doubt, that if the earth were only a few millions of miles more or less distant from the sun, or that if the inclination of its axis were only a few degrees more or less than at present, all its chemical, geological and physiological operations would exhibit corresponding variations.*

For the sake of convenient reference, I shall regard the earth as divided into five zones or isothermal

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* As the law of gravity was first demonstrated by observing the revolutions of planets and their satellites, so will the great laws of physiology and pathology be discovered by means of accurate observations, extended over all parts of the earth, in regard to the influence of climate, geographical position, modes of living, civilization, forms of government, &c. on the physical organization and character, intellectual and moral, of the human race. It would be a great acquisition to our knowledge of the natural history of man, if all governments were to require annual returns of the marriages, births, stature, circumference of the chest, dimensions of the head, (from infancy to the completion of growth,) increase of population, diseases and mortality of all their inhabitants. May we not hope that philosophers will use their best exertions to bring about so desirable an object?

bands, each of which presents a different climate. For example, whenever the mean annual temperature is 80° or upwards, and summer perpetual, the climate is *hot* or *tropical.* According to Humboldt, the mean of the year varies from 80° to 60°, between lat. 30° in north Africa and 43° in Europe; and from lat. 23½° to about 33° north in Asia and America. In this zone, summer greatly predominates over all the other seasons, and the climate may be denominated *warm.* But in the middle latitudes, where the duration of summer, autumn, winter and spring is nearly equal, and the mean temperature of the year varies from 60° to 50°, as in the greater part of Europe, northern Persia, China and most of the United States, the climate should be designated as *temperate.* Where the mean of the year ranges from 50° to 40°, and winter predominates over any of the other seasons, as in central Asia, Russia, Norway, Sweden, Denmark and Poland, in Europe; and Canada, Nova Scotia, New Brunswick and the northern portions of the United States, in America, the climate should be distinguished as *cold.* But in all the desolate regions beyond, in which the mean annual temperature varies from 40° to 32°, or even 0°; and where winter continues from nine to ten, and even eleven months in a few places, the climate should be termed *frigid.*

How striking is the contrast between the botanical and zoological character of these different zones! The first abounds with palms, bananas, sugar, coffee, myrtles, pomegranates and aromatic spices; the second, with oranges, limes, figs, maize, rice, olives, grapes and other delicious fruits; while the third is the favourite

region of the grasses, wheat, barley, rye, oats and a variety of forest trees not found in tropical and warm climates,—nor in the regions of perpetual cold, where only a few species of low cryptogamous plants are produced. In accordance with the foregoing facts, it has been shown by Humboldt, that the strength and continuance of vegetation are in proportion as the temperature rises above 52°, below which it is nearly arrested in all climates;* and that the number of vegetable species in the tropical, temperate and polar latitudes is in the ratio of twelve, four and one; so that *the growth of plants may be regarded as a natural thermometer on a grand scale.*

But as all animals are nourished by plants, or by animals that have lived on plants, it is clear that the capacity of any country to support a numerous and wealthy population, must depend chiefly on climate. For example, throughout the whole of Asia and North America, above latitude 50°, the mean annual temperature is below 52°, and vegetation is arrested for ten or eleven months in the year, while in the coldest places (which are the foci of magnetic power) it falls 60° and 70° below 0° during winter.† The conse-

* The temperature requisite for vegetation, however, varies in different plants. Decandolle says that the radish germinates at 41° F. And it is probable that, in very high latitudes, the process is carried on slowly at still lower temperatures.

† This extreme coldness is owing to the large amount of dry land in the polar regions. And as it is much greater in arctic America than Asia, according to Humboldt, the former is colder in the same parallels. For, as the warming influence of the sun extends only a few feet below the land surface in the polar latitudes, they are very soon cooled down by radiation in winter. But

quence of which is, that in the vast regions of Siberia, embracing an area of 4,010,000 square miles, the number of inhabitants does not exceed 3,600,000, who, from the nature of the climate, are compelled to obtain a miserable subsistence by fishing and hunting.

In the still more desolate regions of British and Russian America, on a territory of 3,650,000 square miles, the native population does not exceed 200,000, who live mostly in snow huts, clothed with skins, and nourished by animals, obtained chiefly from the sea. Without agriculture, commerce, manufactures, or the possibility of uniting together under regular forms of government, they are reduced to a state of complete barbarism; and, like the scattered tribes of northern Asia, are mere dwarfs in stature as in mind.

And if we pass to the elevated plains of ancient Scythia, in central Asia, which is colder than any part

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as bodies of deep water are warmed for several hundred feet during summer, they continue to give out caloric to the superincumbent atmosphere during winter, until reduced to the freezing point, when they present the character of a continental climate. It is therefore manifest, that if the space now occupied by land, above the latitude of 60°, were replaced by an ocean, the temperature of the whole northern hemisphere would be greatly moderated. For example, owing to the prevalence of west winds from the Pacific Ocean, the mean annual temperature of New Archangel, in latitude 57° N. on the western coast of America, is 45·2°, but only 26° on the eastern coast of Labrador, in the same latitude. The western coast of Europe is also several degrees warmer than the east, on account of the prevalent west winds from the Atlantic. Moscow has a much colder winter, in latitude 55° 45′, than St. Petersburg, in latitude 60°; while at Yakutsk, in the centre of Siberia, latitude 55° N. the mean temperature of winter is 38° below 0°, and that of summer 63°, making a difference of 101° F.

of the northern hemisphere in the same latitudes,—* where bleak northerly winds prevail for eight or nine months in the year, vegetation is always imperfect; and, according to Balbi, on a territory of 4,250,000 square miles, the number of inhabitants does not exceed 30,000,000, who, for the most part, lead a wandering or nomadic life, and have never made any considerable progress in civilization, science, literature and the arts, if we except the brutal art of war; so that if we include the whole of North America above latitude 50°, and of Asia above 40°, the population

* Central Asia is bounded on the north by the Altai Mountains, which extend from west to east across the continent,—on the south by the great Himalaya range, which extends from the north of India eastward, and across China, and westward until it takes the name of Hindoo Koo. Between the north side of this and the Kuen-lun range, in north lat. 35°, on the table-lands of Thibit, from ten to fourteen thousand feet in height. Still farther north, in about lat. 45°, on the Thian-Chan Mountains, between which and the Kuen-lun is the great desert of Cobi and the immense plateaus of Tartary, five thousand feet high, at the foot of the Thian-Chan range, so that a large portion of Asia is from one to nearly three miles above the ocean. By means of these lofty barriers, the warm winds which blow during summer from the Indian Ocean are prevented from passing to the interior, and deposit nearly all their vapours in floods of rain, on the southern portions of the continent. In addition to this, the prevalent west winds from the middle latitudes of the Atlantic give out a large portion of their caloric, and deposit nearly all their moisture while passing over Europe, and before arriving at central Asia, becoming cold and dry as they advance eastward. Hence it is that the mean temperature of winter at Edinburgh, in lat. 55° 57′, is 38·6°, while at Moscow, in the same latitude, it is only 10·8°, and about the same in Circassia, 10° farther south.

is only about 33,800,000, on a territory of nearly 12,000,000 square miles.

But in the warm and temperate latitudes of Asia, south of latitude 40°, where vegetation continues from six months, as in the north of China, to ten months, and even the whole year, in the southern portions of the continent, the population is about 400,000,000, on a territory of 6,450,000 square miles. In India, it is 140,000,000 on an area of 1,200,000 square miles;* while in China alone, which contains 1,297,000 square miles, between lat. 20° and 40°, it is about 370,000,000, making an aggregate of 510,000,000 on a territory of 2,500,000 square miles. From which, it may be shown by calculation, that if the climate of northern Asia and America were equally favourable, they might support a population of more than 1,400,000,000 on a territory of 12,000,000 square miles; whereas it is only 33,800,000. And what is their rank in the scale of intellectual and moral enjoyment?

If we pass to the warm and temperate latitudes of Europe, where vegetation continues from six to ten months in the year, and the inhabitants are seldom pinched with extreme cold, or exhausted by excessive heat, the population is about 170,000,000, on a territory of 1,425,000 square miles. In the United States, the climate and soil of which are equally genial and fruitful, there is a territory of 3,000,000 square miles, with a population of 17,000,000, (now 28,000,000,) which, should it go on doubling every thirty-six

* A late report to Parliament gives the total area in square miles, 1,368,113; population, 158,774,065, and perhaps about 200,000,000, if the census were carefully taken.

years, will be 150,000,000 in another century. And if the period of doubling be then fifty years, it will be 600,000,000 in another century.* Nor can there be a reasonable doubt, that improvements in science, agriculture, the arts, and the adoption of a chiefly vegetable diet, will afford the means of supporting in comfort a much greater population to the square mile, than has ever yet existed in any part of the world. And should the colonies of Great Britain, now pouring into many of the best portions of the earth, continue to multiply as at present, the language, civilization, intelligence, wealth and growing prosperity of the Anglo-Saxons must ultimately prevail in every quarter of the habitable globe.

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* But if a lofty chain of mountains extended northwestward across the continent from lat. 24° to 45°, like the Himalayas in Asia, it is evident that the Middle and Northern States would have a climate resembling that of ancient Scythia, the transition from which to the tropical vegetation of India and China is abrupt; whereas in North America it is gradual, from the frozen zone, with its treeless plains, covered with mosses and lichens, to the pine forests of Lake Superior, the oak lands of Wisconsin, the maple, walnut and hickory trees of Ohio, Indiana, Kentucky and Tennessee, and the magnolias of Mississippi, Louisiana and Florida. The traveller also who passes the Alps, descends, by a single day's journey, from the firs of the north, into the evergreen gardens and orange-groves of Italy. As the sovereign of the earth, man has the power of removing forests, draining marshes, dyking rivers, and of improving his condition in an endless variety of ways. But he cannot alter the mean temperature of the earth, nor any considerable portion of it, the thousandth part of a degree, any more than he can prevent the elevation of mountains, the direction of winds or the revolutions of planets. In the City of London, with its 400,000 fires, the mean of the year is but 2° higher than in the surrounding country.

In the north of Europe, including Russia, Sweden, Norway, Denmark and Poland, where the mean annual temperature of the year varies from 38° to 45°, and where vegetation is arrested from eight to nine months in the year, the population is only about 65,000,000 on a territory of 2,074,000 square miles. Owing to the severity of the climate, there is a deficiency of grass and grain for domestic animals; while the demand for fuel, clothing and warm houses requires a corresponding amount of labour; all of which diminish the resources of the people, and retard the progress of civilization, literature, science and the fine arts.* Corresponding with these facts, we are informed by Balbi, that the revenues of Great Britain, independent of her colonies, are nearly three times greater than those of all the nations in the north of Europe.

Nor is it less certain, that excessively hot climates are unfavourable to the population, wealth, civilization, refinement and general prosperity of nations. For, although the tropical zone abounds with delicious fruits and other aliments, it is annually deluged with rains for several months, attended with dreadful hurricanes, and parched with drought during the remainder of the year;† while the frequency of earthquakes

* According to Humboldt, the increase of wheat is from five to sixfold in Russia and Poland; from eight to ten in Hungary; from twelve to eighteen in Greece; in northern Mexico about sixteen; in tropical Mexico and Granada, from twenty-five to thirty-five.

† The reason of which is, that when the sun is south of the equator, there is a perpetual under current of air from the higher and colder latitudes of the northern hemisphere to the tropical zone; where, being expanded, it rises loaded with vapour, and flows back

and volcanic eruptions causes the overthrow of cities, and the destruction of many thousand lives, not to mention the pestilential character of the atmosphere. Such is the deleterious influence of the torrid zone on the growth of population, that in the vast continent of Africa it does not exceed 57,000,000; or if we take the estimate of Balbi, 60,000,000, on a territory of 11,000,000 square miles, a large proportion of which is found above north lat. 30°, where the mean temperature of the year varies from 78° to 68°, and where considerable advances have been made in wealth, civilization, arts, science and social improvements, as in ancient Egypt, Carthage and other Phœnician States.

Owing to there being a much larger body of dry land exposed to the influence of a tropical sun in Africa than in any other part of the world, it has a higher temperature during the hottest part of the day. For it has been shown by Humboldt, that the heat of any country is in proportion to the extent of fixed surface between lat. 40° on each side of the equator, modified by elevated mountains, plains, forests and sandy deserts. For example, tropical Africa is hotter

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as an upper current before the tropical atmosphere becomes saturated or precipitation takes place, causing a drought of six months on this side of the equator. But when the sun returns to the northern hemisphere, the land becomes so heated, even in the higher latitudes, that the under current from the north is greatly diminished, and nearly ceases within the northern tropic. The consequence of which is, that the vapour carried into the atmosphere, instead of passing with an upper current to the higher latitudes, accumulates within the tropics, and is almost daily precipitated in floods of rain, attended with frightful explosions of lightning and peals of thunder.

north than south of the equator; first, because it is broader north of the equator, from which it narrows on to the Cape of Good Hope;* and secondly, because of the great Desert of Sahara, which extends from lat. 15° to 30° N. and from the Atlantic Ocean to Egypt, over an area of 300,000 square miles,—with no mountains, and scarcely any rain, to mitigate the influence of the blazing sun.

The consequence is, that in Soudan, Bennin, Dahomy, Coomassie and other portions of tropical Africa, the temperature rises to 108°, and sometimes to 113°, in the shade, during the heat of the day, according to Denham, Clapperton and other travellers. It also rises to 112° in the hottest parts of New Holland, as we are informed by Mr. Lang—owing to the absence of mountains, the scarcity of rain, and the prevalence of

* If southern Asia extended over the space now occupied by the Indian Ocean, as far as 30° S. interspersed with large sandy deserts, the temperature of tropical India would correspond with that of central Africa, and the whole continent would be considerably warmer than at present. Or, if instead of narrowing from the United States, on to the Isthmus of Darien, North America extended over the space now occupied by the Atlantic as far as the equator, with a breadth of 4000 miles, its climate would have corresponded very nearly with that of Africa in the same latitudes. But as Africa and Asia contain five or six times more dry land between the latitudes of 40° on each side the equator, they are warmer, especially Africa, than America in the same parallels. It may also be worthy of notice, that the western coast of tropical Africa is hotter than the eastern coast, which is somewhat cooled by the trade-wind, which also moderates the temperature of tropical South America on the east. In the same way, the temperature of Southern Asia is moderated by the monsoons which blow from the Indian Ocean during summer.

sandy deserts. Corresponding with this state of things, the native population of New Holland does not exceed 500,000 savage negroes, on a territory of 3,000,000 square miles, which is nearly equal to that of all Europe.

Thus it is, that no great, wealthy, populous and highly civilized nation, has ever existed in either excessively hot or cold climates. If man be dwarfed in stature, and all his higher faculties blunted, by the torpifying agency of intense and long-continued frost —he is equally degraded by the perpetual influence of an elevated temperature, which blackens his skin, renders his hair coarse, harsh and curly, while it impairs the vigour and beauty of his whole organization. For example, the head of the negro is not only smaller in every direction than that of any other race or nation, but the greater part of the brain lies behind a perpendicular line drawn from the *meatus auditorius externus*. The skull is thick and heavy, but narrow or compressed at the sides, the forehead low and retreating, the cheek-bones prominent, the jaws strong, the mouth large, the lips thick and gross, the nose flat, the nostrils wide and the chin small. The fore-arm is longer compared with the humerus than among other nations, the fingers long, slender and sinewy, with nails like claws. Like the lower animals, the thigh is longer compared with the leg, thinner from side to side, and deeper from front to rear, than among the whites or the tawny coloured tribes. The *os calcis* projects backward, the foot is flat and the leg slender, presenting the appearance of a mattock with its handle; while the toes are long and slender, with strong crooked

nails that resemble claws. Such is the outline of the negro, as described by Blumenbach, Prichard, Lawrence, Caldwell and other writers on the natural history of man. It is therefore not surprising that for thousands of years the natives of central Africa have remained in a state of the grossest barbarism,—nor that they have been reduced to slavery by the Egyptians, Phœnicians, Persians, Greeks, Romans and nearly all the nations of modern Europe.

It is certainly true, that some of the most populous, wealthy and highly civilized nations of antiquity, flourished in southern Asia and northern Africa; as in India, China, Arabia, Syria, Egypt, Tyre, Sidon and Carthage. But the climate of these countries is moderate, compared with that of tropical Africa and New Holland; or intermediate between what I have denominated hot and temperate climates. For example, the mean annual temperature is 70° at Algiers; in winter it is 61·4° and 82·8° in summer; while at Cairo in Egypt, the mean of the year is 72·4°, that of winter 58·4°, and that of summer 85·8°. Corresponding with this intermediate climate, is the physical character of the natives, who are neither black nor white, but dark-brown, olive or yellow, with long and slightly curled hair, regular features, sparkling eyes, slight but muscular frames, well formed heads and a considerable share of intelligence.

Yet among all the monuments of southern Asia and northern Africa, there is nothing in architecture, sculpture, poetry, painting, &c. equal to the finest models of Greece. Such a climate, says Hippocrates, produces not only the most beautiful of men, but harmony be-

tween the inclinations and form of the body. Winkleman also observes of the Grecian excellence in sculpture and painting, that the happy situation of the country was the basis of all. But there is reason to believe, that in the still more uniform climate of Great Britain, where the grass is rarely killed by frost, or parched with excessive heat, but remains green throughout the year, man has arrived at greater size, strength and longevity, including all the endowments of a vigorous physical, intellectual and moral organization, than in any other part of the world: for it produced Bacon, Shakspeare, Milton, Chatham and Watt, who have surpassed all the poets, philosophers, orators and inventors of antiquity. The population of a small island has acquired more wealth and power than was ever possessed by any other nation; and has done proportionally more toward the diffusion of useful knowledge throughout the civilized world. We are also indebted to Germany, whose climate is nearly the same as that of Britain and France, for the noble invention of printing, the great discoveries of Copernicus, Kepler, and Humboldt, who is the greatest naturalist of the nineteenth century.

It has been said that "there is nothing more difficult to explain fully, than the immense superiority of Europe over the other quarters of the world." But I shall endeavour to show that it is because the climate of middle and southern Europe is more temperate and uniform. In the first place, there is nothing better established by history, than the superiority of man in temperate latitudes. The once populous and wealthy nations of Egypt and Syria were conquered by the

Persians, Medes, Greeks and Romans,—the Chinese by the Tartars,—Italy by the Germans, Goths and Huns,—northern Africa by the Romans,—and the East Indies by the British, who are now invading China.

In the middle latitudes of Europe, the mean temperature of winter varies from 38° to 40°, and that of summer from 58° to 66°; while in the south of Europe, it is from 45° to 52° in winter, and from 70° to 75° in summer. The mean difference, therefore, between winter and summer, varies from about 20° to 25°; and the average of the year is from about 50° to 60°, while the annual extremes are from about 10° in winter, to 85° or 90° in summer. In the north of Europe between lat. 50° and 60°, the mean annual temperature varies from 50° to 38°,—that of winter from 30° to 10°, and that of summer from 62° to 69°; —so that between the mean of winter and summer, the difference is from 39° to 52°, while the annual extremes are from 120° to 130°.

In the United States, the mean temperature of the year between lat. 48° and 30°, is nearly the same as in Europe between lat. 35° and 60°;* and varies from about 40° in the north, to 60° and upwards in the south. But owing to the greater amount of dry land

* Owing to the prevalence of winds from the Atlantic during the greater part of the year, the west of Europe has a maritime climate, and a higher mean temperature than Asia or America, in the same latitudes. But, as Humboldt observes, this is owing in part to the heating influence of Africa, from which Europe is separated on the south only by the Mediterranean; and partly to the small amount of land in the polar latitudes.

in polar America, and the absence of an ocean wind from the west, the extremes of temperature are much greater east of the Rocky Mountains than in the same latitudes of Europe. For example, in the Canadas, Nova Scotia, New Brunswick and the States north of 42°, the mean of winter varies from 14° to 34°, and sometimes falls 31° or 40° below 0° during the coldest days; while the mean of summer is from 64° to 70°, and often rises to 95°, or even 100° in the shade, during the heat of the day,—making the mean difference between winter and summer from 50° to 36°, and the annual extremes from 130° to 140°.

In the middle States between 42° and 36°, where the mean of the year varies from near 60° to 50°, that of winter is from 35° to 27°, of summer 76° to 72°, making the difference from 45° to 41°, and nearly double what it is in the middle and southern latitudes of Europe, where the annual extremes rarely exceed 90°, whereas in the middle United States they vary from 100° to 120°. In the southern States, the mean temperature varies from about 60° to 70°, while that of winter is from near 40° to 50°, and the number of growing months from seven to ten. In the middle States, they are from six to seven, and above latitude 42°, from four to five. As for the rest, the extremes of temperature diminish as we proceed from north to south in all climates of the northern hemisphere, *cæteris paribus*.

At Pekin in the north of China, and lat. 39° 54′, corresponding very nearly with the parallel of Philadelphia and Cincinnati, the mean temperature of the year is nearly the same, or 55·2°. But that of winter

is 26·8°, and that of summer 82·6°, making a difference of nearly 56°, which is 21° higher than in the same isothermal zone of Europe; 11° higher than in the middle States of America, and greater than in Russia, Nova Scotia or Canada. Owing to its exposure to the bleak winds of Tartary, and the hot winds from the south, the climate of northern China approximates that of the polar regions during winter, and that of the tropics during summer. The truth is, that scarcely any part of Asia possesses what may be called a temperate climate, if we except that portion termed Asia Minor, which lies between the Mediterranean and the Black Sea. For, in the regions south of the Himalayas, and in nearly the whole of Asia Minor, there are but two well-marked seasons, the dry and the rainy; while in the vast plains beyond that immense chain of mountains, and from the Caspian to the Polar Sea, the only seasons are a long and rigorous winter, followed by a brief, dry and unfruitful summer.

But in the temperate latitudes of Europe between 35° and 55° north, there is a delightful succession of winter, spring, summer and autumn, with frequent alternations of sunshine and gentle showers, if we except the summer droughts of Greece, Italy and the south of Spain. The same observations apply to the United States south of latitude 42°, and where the temperature is never tropical during summer, for more than a few weeks, nor polar in winter, beyond a few days, and but seldom. Throughout the greater part of this beautiful and fertile country, the climate is strictly temperate, and far better adapted to the support of a numerous, wealthy and highly civilized popu-

lation, than that of China, India, Persia or any other portion of Asia.

Let us now examine how far, and in what way, the stature, strength, form of the body, size and configuration of the head, are modified by climate or external temperature. In the first place, then, it would seem to be a law of nature, *that in man and all the higher animals, respiration is augmented in proportion as the surrounding temperature falls below the point at which they are capable of maintaining themselves at the natural standard, but diminished in proportion as the atmosphere rises above that point,* cæteris paribus.

For example, it was ascertained by Dr. Crawford, that when a Guinea pig was taken from the air of a room at the temperature of 61° and confined in air surrounded with water at 55½° for forty-two minutes, it expired double the amount of carbonic acid as when kept in air at 104° for the same time. In another experiment he found that on surrounding a Guinea pig with air at 36°, it generated three times more carbonic acid in the same time, than when made to breathe air at 102° F.* (*Experiments and Observations on Animal Heat*, pp. 311, 387.)

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* In the *Memoirs of the French Academy of Sciences* for 1789 are recorded some experiments performed by Lavoisier on M. Seguin, a vigorous young man, who consumed 1344 cubic inches of oxygen per hour, when surrounded with air at 59°, and 1210 cubic inches, when supplied with air at 91°. From which it would appear that respiration was diminished only 10 per cent. by elevating the surrounding air 32°, or from 59° to 91°, which is about the difference between the temperature of London or Paris, and that of the tropics. It also follows from these results, that the average amount of respiration is only 25·62 per cent. greater in

Now if these experiments are to be relied on, and the first of them be taken as a standard, it follows that respiration is diminished 100 per cent. by elevating the temperature of the air 48°, which is the difference between 55° (omitting fractions) and 104°, without taking into account the hydrogen that unites with oxygen in the lungs. It would also follow, that in the polar regions, where the mean temperature is at 0°, 104 per cent. more caloric is obtained by respiration than in the middle latitudes where the air is at 50°,—170 per cent. more than within the tropics where the annual average is 82°,—375 per cent. more during winter in the polar regions, where the temperature is 70° below 0°, than where it is at 110°, as in central Africa,—and 416 per cent. more than at 130°, as when exposed to a tropical sun. But if we take the

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polar America than within the tropics, and 62·5 per cent. more at 70° below 0°, than at 130°, as when exposed to an African sun. And as the density or specific gravity of elastic fluids is diminished 100 per cent. by 480° of heat, (see vol. i., *page* 120,) it follows that the same volume of oxygen would weigh 6·66 per cent. more at 50°, (the mean temperature of London) than at 82°; and 17 per cent. more at 0°. Corresponding with these facts, it has been observed by the manufacturers of iron in Europe and the United States, that more caloric is obtained by ordinary combustion during winter than summer, especially when the air is sultry and saturated with vapour, which carries off a large amount of caloric in a combined or latent state; and that a larger amount of fuel is required to perform the same duty, than when the air is cold and dry. It is not true, however, that sunshine puts out a common fire, as the vulgar suppose, but it is rendered invisible or obscure by the superior lustre of the sun. Yet Dr. M'Keever found that in a dark room at 63°, one inch of a common candle was consumed in fifty-six minutes, but required fifty-nine minutes in strong sunshine at 80°.

mean results of Crawford and Lavoisier, it may be found by an easy calculation, that 38 per cent. more oxygen is consumed at 50° than at 82°,—97 per cent. more at 0°,—215 per cent. more at 70° below 0° than at 110°,—and nearly 240 per cent. more than at 130°.*

Again, as I have shown it to be a law of nature, that *the aggregate forces of life in animals are in proportion to the amount of caloric that passes through their tissues in a given time*, it might be supposed that they are more energetic in the polar regions than in temperate, warm and tropical climates. But notwithstanding the large amount of caloric obtained by respiration, it is still more rapidly abstracted by the surrounding air, in excessively cold climates, and before it has time to perform fully its life-giving office of nourishing the solids. Hence it is that the average height of the Tartars† on the eastern coast of Asia does not exceed five feet three inches English, according to the measurements of M. Rollin, who accom-

* According to the later experiments of Letellier, about 100 per cent. more carbonic acid is exhaled by warm-blooded animals at 0°, than at 104° F. (*Kirkes and Paget's Physiol.* p. 135.) It is therefore manifestly not true, as maintained by Liebig, that the increase of respiration by cold is owing merely to the greater density of the atmosphere, which is only about $16\frac{2}{3}$ per cent. less at 80° than at 0°. In other words, the mean density of the atmosphere is only one-sixth less in the tropical than in the polar regions, where the average amount of respiration is nearly 200 per cent. greater.

† And Pallas informs us, that the Mongolian Tartars generally, are greatly inferior in muscular strength to the Russians, who are inferior to the British and Germans.

panied the expedition of Perouse; while it is known that in the frozen regions of Siberia, Lapland, British America and Terra del Fuego the natives vary from four and a half to five feet in stature, with remarkably small hands and feet, as if their growth were stinted by exposure to extreme cold. And although the head is sometimes large, the perceptive, intellectual and moral organs are imperfectly developed, as shown by the smallness of the superciliary ridges, lowness of the forehead and flatness of the coronal region,—corresponding with their want of sensibility, the more refined emotions of love and all the higher endowments of genius.* They are also exceedingly ugly and ill-formed. The skin is rough and thick, the hair straight and coarse, the beard scanty, the face broad and flat, the nose short, the eyes narrow and oblique, the cheek-bones prominent, the mouth and ears large. In fact, the habitual sensation of pain, produced by extreme coldness of the air, or even by disagreeable mental emotions, tends to distort the features, which are rendered placid, regular and beautiful by perpetually agreeable sensations, whether excited by physical or moral causes. Every thought and emotion that affects the muscles which give expression to the face, gradually, though insensibly, modifies its character in a long course of time.

The thorax is also much larger in proportion to the whole body, among the Esquimaux, Samoiedes,

* Crantz tells us, that the mental faculties of the Esquimaux present a continued childhood; while they are selfish, cruel, deceitful, ungrateful, filthy and gluttonous; in short, that they have no real virtue. (*Hist. of Greenland*, vol. i. pp. 135, 188.)

Yakouts, Tungouses, Finlanders, Laplanders, and even the Tartars of central Asia, than among the nations of temperate climates, as we learn from Pallas, Forster, Hearne and other travellers, who represent the chest and shoulders as so broad as to give the appearance of deformity. This peculiar conformation of the thorax in excessively cold climates, is doubtless owing to the continual necessity of exercising the lungs, by which their development is augmented, for the purpose of compensating the rapid loss of animal heat. For, whenever caloric is abstracted from the body faster than it is supplied by respiration, a painful sensation of chilliness is produced, which, like the cold bath, prompts the individual to take more full and frequent inspirations.

Moreover, owing to the large demand for fuel to support combustion in the lungs, the inhabitants of the frozen zone require a corresponding amount of animal and oily food, of which an Esquimaux devours from ten to twenty pounds a day, according to Sir John Ross,* who says: "the *true secret of preserving life, in the polar regions, is a large use of fat meats.*" He adds, that men of weak digestion, or of the melancholy and phlegmatic temperament, cannot endure cold like those of perfect digestion and vigorous constitution. (*Narrative,* pp. 200, 448; 1835.) And Sir

* From this account, it would appear that the inhabitants of the polar regions consume during winter from four to eight times as much food as those of temperate climates; so that if the whole of it undergo combustion in the lungs, the amount of heat evolved would very soon destroy life, if not as rapidly carried off by the intensely cold atmosphere in which they reside.

John Franklin observes, that "during the whole of our march, we experienced that no quantity of clothing would keep us warm while we fasted; but if enabled to go to bed with full stomachs, we passed the night in a warm and comfortable manner." (*Journey to the Polar Sea* in 1819–22, p. 447.) We are also informed by Claridge, that at Gräefenberg, in Germany, where the celebrated Priesnitz subjects his patients to the cold bath, from fifteen minutes to an hour, three times a day, and makes them drink from ten to twenty glasses of cold water in the same time, for the cure of all diseases,—they consume an enormous amount of animal food and pastry,—that "the water cure gives an appetite, and forces the invalid to eat more than he was accustomed to in health."* (*Hydropathy*, p. 254.)

On the other hand, in the tropical portions of India, Africa, America and New Holland the thorax is narrow, flat, and its circumference considerably less than in the higher latitudes, according to the best information I have been able to obtain from writers on the natural history of man. The reason of which is, that whenever the temperature of the atmosphere rises above the point at which the body is capable of maintaining itself at the natural standard, the caloric ob-

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* It is therefore manifest, that men require a more abundant supply of animal or oily food when exposed to intense cold, and are badly clothed, than when protected by warm houses and garments. Nor could the patients of Priesnitz obtain a sufficiency of animal heat by respiration to keep them alive under his cruel practice, without an abundant supply of oleaginous food, or such as abounds with carbon and hydrogen, as will be further shown when I come to treat of aliments.

tained by respiration is not carried off, as at lower temperatures, but accumulates in the system, producing a disagreeable sensation of preternatural warmth, the tendency of which is to diminish the action of the lungs and the generation of caloric. By means of this admirable instinct, founded in the natural aversion to pain, whether from excessive heat or cold, men and other animals are prompted to accommodate the amount of respiration to the wants of the system, in different climates and seasons.

But it is not only respiration that is from thirty to thirty-eight per cent. less in tropical than in warm and temperate climates, like those of Greece and Italy, France and England; for I have proved that secretion, nutrition, or the formative process by which the composition and vitality of the body are maintained, depend on the transition of caloric from arterial blood to the solids. It is therefore evident that the aggregate forces of life must be diminished in proportion as the temperature of the solids approximates that of the arterial blood.* Hence the debilitating influence of

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* But as in the hottest climates the atmosphere is seldom above the natural temperature of birds, it is obvious that in them the process of nutrition, and the general powers of life, are much less impaired than in the active mammalia; and less in most of the latter, such as the dog, wolf, fox, sheep, ox, horse, deer, hog, &c. than in man, whose average temperature is several degrees lower. Hence it is, that warm and hot climates are more favourable to the growth, strength and health of birds than of mammalia, if we except the monkey tribes, the elephant, camel, rhinoceros, lion, tiger, leopard and a few other species whose lungs are not sufficiently developed to maintain their temperature during winter in the higher latitudes without artificial warmth. Nor could man exist in cold climates

the hot bath when continued for any considerable time. But what else is the burning atmosphere of tropical climates than a heated air bath? And hence the invigorating influence of the tepid bath in such climates, or even of the cold bath, when employed for a short time, as it then augments respiration. It is also of still greater importance in all cases of preternatural or febrile temperature, by reducing the solids to the natural standard, so as to favour the nutritive process, which cannot be carried on without the transition of caloric and arterial blood to the solids. Nor is it possible that fever, or any other constitutional malady, can exist, so long as this process is carried on in the natural manner,—or so long as the blood is constantly renovated in the lungs and depurated by excretion. *But the employment of cold must never be carried so far as to reduce the system below the normal standard, as it then diminishes the power of the heart, the circulation of blood through the lungs, and therefore the process of respiration, on which all the other functions of the animal economy depend,*—for the same reason that all the movements of the atmosphere, evaporation and rain, the operations of chemistry, geology and the growth of plants depend on the heating influence of the sun.

Some experiments of Dr. Edwards clearly prove

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without the aid of fires, or plenty of food and warm clothing. Sir Charles Morgan observes, that in such climates "the whole energy of life is expended in maintaining temperature." (*Philosophy of Life*, p. 434.) He might have said that heat is so rapidly abstracted as greatly to diminish the powers of life, which are very soon annihilated without a due supply of that important agent.

that, like mammalia, birds obtain more caloric by respiration during winter than summer. For he found, that when five adult sparrows were placed in a vessel through which there was a free circulation of air, (with a solution of pure potassa to absorb the carbonic acid exhaled,) they lost only ·72° of temperature in one hour, in the month of February, when the air was at 32°. But when the same species of birds were placed in air reduced to 32° in summer, by means of a freezing mixture, they lost from 6·5° to 10·8° in one hour, and 21·6° in three hours.*

When the lungs have become adapted to the temperature of summer, they do not suddenly accommodate their action to that of freezing water. Hence it

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* Yet he maintains, in a recent article on Animal Heat, contained in the *Cyclopedia of Anatomy and Physiology*, that *respiration is augmented by the high temperature of tropical climates*, and the heat of the body increased until the condition becomes pathological, as in fever. (Vol. ii. p. 679.) He adds, in another place, that as the proportion of red globules in the blood exerts an important influence on the generation of heat, that of fever may be reduced by bleeding and low diet. Dr. C. Holland also maintains that the effect of a high temperature is to produce a more oxygenated state of the sanguineous fluid,—which he thinks predisposes to fever and other tropical diseases. (*Laws of Organic Life and Principles of Medicine.*) From which it would appear, that both of these intelligent physiologists imagine, that an increase of respiration and generation of animal heat are essential to the existence of fever. But I have proved that the proportion of red globules in the blood depends on the amount of respiration, which is always diminished by an elevated temperature. Nor does fever depend on the quantity of caloric obtained by respiration, but on a deranged condition of the blood, by which it is prevented from passing to, and combining with, the solids.

is, that all rapid transitions from heat to cold, and from cold to heat, are unfavourable to health; that when the natives of the higher latitudes are removed to hot climates, they generate caloric by respiration faster than it is carried off, and are therefore liable to fever, which should be prevented by a cooling diet of fruits and vegetables, frequent cold ablutions, or by bathing in cold water, until the body is reduced to the natural standard, or to the point of actual comfort. On the other hand, when the natives of hot climates are removed to the higher latitudes—owing to the smallness of their lungs, they do not obtain caloric by respiration so rapidly as it is wasted,—which renders them liable to disease of the lungs, rheumatism and other inflammatory affections.

Corresponding with what has been said of the diminished respiration in hot climates, the natives of central Africa, (including the great Desert of Sahara,) New Holland, New Guinea, Sumatra and Borneo, are greatly inferior in stature, muscular strength, size and configuration of the brain, beauty of features, intellectual and moral endowments, to the inhabitants of temperate and warm climates. For example, Mr. Lawrence found the average height of five negroes, who were descended from native Africans, to be five feet six inches. And it is stated in the *Phrenological Journal*, by the surgeon of the ship Blossom, commanded by Captain Beechy, that the general height of the negroes brought from tropical Africa to Rio Janeiro was about five feet five inches.* (Vol. iv. p. 624.)

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* The tendency of a hot and malarious climate is to produce habitual indolence, which prevents the development of the whole

Nor is it less certain, that the Affghans of northern India are a large, athletic and powerful race, compared with the tropical Hindoos, who, although evidently belonging to the same original stock, do not exceed five feet six inches in height. The same difference exists between the northern and southern Chinese,—the natives of Persia, Turkey, Georgia, Circassia,—and the Arabs of southern Asia and northern Africa, including the Egyptians. The Patagonians, the Araucoans of Chili and other tribes that inhabit the temperate latitudes of South America, like the North American Indians in corresponding latitudes, are also much larger, stronger and more courageous than those of Brazil, Paraguay, Mexico and Peru, who, like the Eboes, Gaboons, Mandingoes and other blacks of tropical Africa, New Holland and New Guinea, have always been a feeble, indolent and servile race. As we advance from the middle latitudes of America to Cape Horn southward, or to the Arctic Ocean northward, man diminishes in stature until the average does not exceed four and a half or five feet.*

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organization, and especially that of the brain. Owing to the want of due exercise, the legs of the negro are slender and the calf defective. His jaws being more employed than his brain, are like his cheek-bones, prominent; his lips thick, his mouth open and large, his nose broad and flat. But activity of the brain calls into exercise nearly all the muscles of the face, including the *alæ nasi;* which causes the vomer to rise, lessens the protuberance of the jaws and modifies the whole visage.

* The horse, ox, deer, sheep, goat, dog and some other domestic animals are also larger, better formed and more vigorous in the middle latitudes than in either the tropical or polar regions. And although the elephant, rhinoceros, hippopotamus, giraffe, lion, tiger

There is nothing in the history of our race more certain, than that in all the attributes of a vigorous and beautiful organization, man has attained to the highest perfection in the temperate zone. How striking is the contrast between the tall European, with his high and expanded forehead, large, bright and intelligent eyes, oval face and well-marked features, compared with the low, thick stature of the northern Asiatic, with his square head, flat face, large cheek-bones, low forehead, broad nose, small eyes* and ill-defined features; or with the black skin, coarse woolly hair, large mouth, thick lips, broad flat nose, advancing jaws, diminutive forehead and dull eyes of the African! The Berbers of north Africa, like the Caffres of the south, are also greatly superior in strength, activity, symmetry of form, regularity of features and intelligence, to the tribes of the interior, who are distinguished by low cunning, cruelty, cowardice and sensuality.

The climate most favourable to a high development

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and some other mammalia attain to very great size within the tropics, they have less strength and activity, in proportion to their size, than animals in the middle latitudes.

And if reptiles are larger in hot than in cold climates, it is because their respiration is imperfect, and arrested for six or eight months in the higher latitudes, during which they cease to grow; whereas within the tropics, they continue to grow throughout the year.

* The contraction of the aperture of the eyelids in the Tartars and other northern nations, was doubtless produced by the habitual effort to protect that delicate organ from the cold, piercing winds, and the glare of light reflected from the snowy ground, as they had no fixed habitations to protect them from the elements.

of the human race, would seem to be one in which the mean annual temperature approximates that of the whole earth, which is about 58°, and in which the variations are small, as in the middle latitudes of Europe, where the average of summer is seldom more than 10° above the mean of the year, and that of winter rarely more than 10° below the same standard. For man has attained to larger stature in Great Britain, Germany, Holland, Belgium, Prussia, Sweden and Russia, than in any other quarter of the world. It was long supposed that the natives of Patagonia were larger than those of any other nation. Yet we have no recent authentic account of any individual of that tribe who measured above six feet six inches and a fraction, or more than forty-eight inches around the thorax, according to Wallace and Cordova. They are even inferior to the Osages and Blackfeet Indians of North America, who are sometimes above seven feet in height, according to Catlin.

But the Irish giant, whose skeleton is now in the London College of Surgeons, measured eight feet four inches. There have also been men in England, Scotland, Hanover, Prussia, Sweden, Denmark and Russia, above eight feet in height, and some who have measured fifty-two inches around the thorax, without being unusually fat. According to numerous measurements of M. Quetelet and Professor Forbes, the average stature of the Irish, Scotch and English adult students in the Universities of Cambridge and Edinburgh, is above five feet nine inches; which exceeds that of the French and Belgians, who are taller than the inhabitants of Spain, Portugal, Italy and Greece. The

beautiful statue Adonis was five feet eight inches, and that of the Venus di Medici about five feet; which may be regarded as the mean stature of the men and women of southern Europe.*

We also learn from Professor Forbes, that the better classes in Ireland are taller, heavier and stronger, than the same classes in Scotland, who are superior to the same classes in England.† Is this because the tem-

* There is reason to believe that in all parts of Europe, the finest specimens of manly beauty, strength, activity and intelligence, have been found most frequently among individuals of moderate stature, corresponding with the Grecian model; which may therefore be regarded as an example of the perfect average man. Alexander the Great, Julius Cæsar, Cromwell and the Duke of Wellington, were of nearly the same stature as that of the Adonis, and Napoleon considerably less. It is evident, however, from all the foregoing facts, that the average stature of man varies in different climates.

† For example, the mean height of the Irish, with shoes, was 70·2 inches; of the Scotch 69·3; of the English 68·9; and of the Belgians 68·3, which is, perhaps, very near the average among the northern French and Germans. But among eighty students of Cambridge, (belonging chiefly to the aristocracy of England, which are somewhat taller than the lower orders,) M. Quetelet found the average height to be five feet nine inches and three-fifths, which is considerably above the average stature in both the north and south of Europe.

Recently, Mr. Macdonald has found the mean stature of 562 men of the middle and upper classes in England, Scotland and Ireland, to be 68·5 inches; while that of the lower and middle classes is about 67·5 inches. He also found the average height of 2000 infantry soldiers (Royal Highlanders) to be 68·25 inches, and the circumference of the chest $38\cdot\frac{10}{16}$ inches. In eleven counties of Scotland the mean height varied from 67·33 to 68·5 inches, and the circumference of the chest from 38·71 to 41·01 inches. But among 1439 town and country recruits belonging to the London

perature of Ireland is more uniform, being less exposed to the cold east winds from the continent, and more open to the prevalent west winds from the Atlantic? or is it because the Irish consume less animal food and more potatoes? In favour of the former hypothesis it may be observed, that in the maritime climate of Japan, the natives are larger and stronger than in the same latitudes of China, where the extremes of summer and winter are great;—that in the tropical islands of the Pacific, where the temperature is mild and uniform, the inhabitants are much larger, stronger and better formed, than in the same latitudes of Africa, Asia, South America and New Holland, where the temperature rises twenty or more degrees higher, and falls as many degrees lower at night. For tropical islands are perpetually fanned by the trade-winds, the temperature of which varies only a few degrees.

In regard to the influence of climate on the size and configuration of the brain, we are yet greatly wanting in accurate information. But some valuable facts have been collected and published by Dr. Morton, in a work entitled *Crania Americana*,—from which it would appear, that among the least educated classes of the English, Scotch, Irish, Germans, Swiss, Dutch and Anglo-Americans, the head is larger than among any other race. That this difference depends more on climate, geographical position and other physical influences, than upon civilization, would appear from the

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District, the average height was 5 feet 8 inches, and the mean circumference of the chest 32·47 inches. (*Johnston's Phys. Atlas, Ethnographic Map of Europe.*)

fact, that he found the mean capacity of the skull greater in three Esquimaux, than in seven Chinese, in the ratio of eighty-six to eighty-two cubic inches;—greater among the barbarous tribes of America, who reside in the temperate and higher latitudes, than among the partially civilized Peruvians, in the ratio of eighty-two and eighty-four to seventy-six cubic inches, and seventy-nine in the Mexicans. The head is also larger among the Tartars than the Chinese, Hindoos and other inhabitants of southern Asia. But if the barbarous tribes of America and Asia have larger heads than the Chinese, Hindoos, Egyptians, Peruvians and Mexicans, it is because in the former the inferior organs greatly predominate over the anterior and superior, which are small in all savages, and are gradually developed by culture. Hence the selfish, warlike and depraved character of man in the barbarous state,—and which can be radically cured only by improving his intellectual and moral organization.

The relative capacity of the skull in what has been called the five different races of mankind, was ascertained by filling it with white pepper-seed, which was afterwards measured, and is represented in the following table of Dr. Morton:—

	Number of skulls.	Average.	Capacity in cubic inches.	
Caucasian	52	87	from 109 to	75
Mongolian	10	83	93	69
Malay	18	81	89	64
American	147	80	100	60
Ethiopian	29	78	94	65

Thus we perceive, that the brain is nearly as large among the savage tribes of northern America and

Asia, as among the civilized inhabitants of Europe, and smaller among the tribes of central Africa and America, than among any other people, excepting the natives of tropical America. M. d'Orbigny says "that a Peruvian is not less different from a Patagonian, and the latter from a Quarani than is a Greek from an Ethiopian or a Mongolian." (*L'Homme Américain*, vol. i. p. 122.) It is not, however, so much in the aggregate volume or weight of the brain that the superiority of man consists, as in the development of its anterior and superior portions; moreover, if the brain of the negro were of the same size and form as that of the European, it would still be inferior in firmness of structure, and therefore in power, because not supported by so large a thorax, not supplied with such an abundance of good arterial blood, the vital properties of which depend on the amount of respiration, (*cœteris paribus*,) which is diminished by an elevated temperature of the atmosphere, as will be further proved when I come to treat of temperaments. In fact, the inferior organization of the negro brain must be ultimately referred to his inferior vitality, which renders him indolent, and prevents the improvement of his faculties by exercise.

Should it be urged that the magnitude and form of the head, on which the intellectual and moral character of nations so much depends, are determined chiefly by regimen, modes of living, political, religious and social institutions—I reply, that all of these are no less modified by climate than the geographical distribution of plants and animals:—that if the natives of the polar regions live chiefly on flesh, and clothe themselves with skins, it is because the climate does

not afford grain, grass, fruits, cotton, flax, wool and silks; all of which abound in warmer latitudes:—that if the Budhists, Brahmans and Essenes, of southern Asia, abstained from animal food and spirituous liquors, it was because they are injurious to health in hot climates:—that if, like the priests of Egypt, they enjoined the frequent use of the cold bath as a religious duty, it was because they found it salutary in a burning climate:—that if they had resided in Russia, they would have substituted in its place warm bathing, which the Russians regard as a panacea:—that if the laws of Moses against the use of pork, hares, rabbits, all carnivorous animals, shell-fish and fat of every description, were adapted to the climate of Palestine, they are constantly violated by even the Jews, in the higher latitudes of Europe, Asia and America; for the plain reason that no laws will ever be long and widely obeyed, unless founded on, and in harmony with, those of nature.

Thus it is manifest, that the diet, clothing, habitations, manners, customs and religious ceremonies of mankind are greatly modified by geographical position,—that "creeds and morals vary in every clime, growing like herbs upon the soil,"—that the physical character of nations, and even their political institutions, depend greatly on the region in which they are created. For in countries where the climate is unfit for agriculture, the population must necessarily be poor, thinly scattered and separated into numerous tribes of wandering shepherds, robbers and hunters, who cannot unite under regular forms of government, nor make any considerable progress in civilization,

arts, science and general improvement. As the higher intellectual and moral faculties are but little exercised, they are imperfectly developed, and the animal feelings greatly predominate.

But in countries where the population is dense, all the higher faculties are stimulated to exertion, by the prospect of obtaining wealth, pleasure, distinction or power,—which are both the cause and effect of improvement of the nobler faculties. Even the organs of voice are modified by climate. The voice of man becomes less adapted to singing as we pass from the south of Europe to the north, until in the polar regions it degenerates to a hoarse whistle. Northern voices are said to be dry, harsh and strident, while southern are liquid, soft and flexible. Northern languages abound in consonants, mutes, gutterals and strong aspirates; southern, in vowels and liquids. And, as among barbarous tribes, the objects are few about which the mind is employed, language is poor, or deficient in copiousness and variety. On the other hand, I fully agree with Mr. Lawrence, that "bad government, oppressive laws, neglected education, bigotry, fanaticism and religious intolerance will counteract the noblest gifts of nature, and plunge into ignorance, degradation and weakness nations capable of the highest culture, the most splendid moral and intellectual achievements." If the climates of India and China are less favourable to a high development of physical, intellectual and moral endowments, than those of Europe, the inhabitants have also been kept stationary for the last 2000 years by the institution of castes, and the misfortune of a hieroglyphic language;

so that the finest portions of Asia are buried in profound darkness, or prevented from improving their condition; while in Russia the mass of the people have been hitherto degraded to the condition of serfs, and sold with the estates on which they labour, like beasts of burden. It is also worthy of notice in this connection, that even in the fine climate of Ireland, a number of people who were driven from the counties of Antrim and Down, toward the sea-coast, about 200 years ago, where they have lived ever since in great poverty and mental degradation, exhibit the most repulsive features,—projecting jaws, large and open mouths, depressed noses, high cheek-bones, with bow-legs, slender limbs and small stature.

CHAPTER II.

"If the human mind can ever flatter itself with having been successful in discovering the truth, it is when many facts, and these facts of different kinds, unite in producing the same result."—BAILLIE.

It is still an unresolved problem among philosophers, whether all the varieties of mankind have resulted from the influence of climate, geographical position, and different modes of living, as supposed by Herodotus, Diodorus, Hippocrates, Buffon, Zimmerman, Forster, Herder, Smith and some others,—or from an original difference of race, as maintained by Voltaire, Humboldt, Adelung, Caldwell, Lawrence, Morton and others. The most prevalent hypothesis of the present day is, that all the nations of the earth may be traced to different races, which have been mingled by conquests, colonizations, marriages, &c. Without denying that all of them may have descended from the same original stock, Blumenbach has reduced the whole to five distinct classes, which he terms the *Caucasian*, the *Mongolian*, the *Malay*, the *American* and the *Ethiopian races.*

To the first of these classes belong the Hindoos, Arabians, Persians, Egyptians, Lybians, Phœnicians, Greeks, Romans, Saxons, Celts, with their descendants, now spread over Europe and many other parts

of the world. To the second, or Mongolian family, belong the ancient Scythians and their descendants, the modern Tartars of central Asia, the Chinese, Japanese, the Indo-Chinese and the various tribes of northern Asia. To the Malay race belong the natives of Malacca, Borneo, Sumatra, Java, New Zealand, the Philippine and other islands of the South Sea. The fourth class embraces the numerous tribes of America, from the Arctic Ocean to Cape Horn; while the black natives of central Africa, New Holland and New Guinea, belong to the fifth, or Ethiopian race.

It is maintained by Mr. Lawrence, in his very able and learned work on the *Natural History of Man*, that "external agencies, whether physical or moral, will not account for the bodily and mental differences which characterize the several tribes of mankind; and that they are the offspring of natural differences in the breed or race." (*Pages* 300, 387, 442, 486.) M. Quetelet also observes, in his late *Treatise on Man*, that "different races must be admitted, although the characters on which these distinctions are established have not been sufficiently defined." And he adds, "how can we study the modifications which the elements relative to man, as well as their laws of development, undergo in the different races, *when we have not settled the point of commencement?*"

In regard to the first abode of mankind, termed the Garden of Eden, or the terrestrial Paradise, various opinions have been advanced by different nations and individuals. By some of the Hindoos, it is supposed to have been situated in the beautiful vale of Cashmere; and by others in the tropical island of Ceylon. San-

son, Roland and Calmet, have placed it in Armenia, between the sources of the Tigris and Euphrates,—Abram, Le Clerc and Heidegger, in Assyria near Babylon,—others in the neighbourhood of Damascus,—others in Arabia Felix,—and some in Palestine. Among the curious speculations of that great man, Christopher Columbus, was the hypothesis that the Garden of Eden was situated near the head-waters of the River Amazon, in South America, which he persisted in regarding as a portion of the Asiatic continent. The latest opinion I have met with on the subject, is that of Mr. Luke Burke, who maintains that the primary centre of civilization was the long-lost island of Atlantis, described by Plato, who pretends to have received his account of it from Solon, who received it from an Egyptian priest. (*Ethnological Journal*, No. 3, p. 138.) But the most improbable of all the hypotheses I have met with is that of Buffon, Adelung and Herder, who supposed that mankind began their existence on the elevated table-lands of central Asia, or about Mount Caucasus, where the climate is extremely rigorous during the greater part of the year. For if the human race began in a rude state of nature, ignorant of agriculture and the arts, it must have been in a tropical or warm climate, in which the earth would spontaneously supply an abundance of nutritious fruits. Nor is it possible, that men could have existed in the climate of central Asia without clothing, unless covered with hair.

If we are to take the description of Eden contained in the second chapter of Genesis, it would seem to have embraced a large portion of southern Asia, ex-

tending from the Ganges on the east, to the Euphrates on the west. For it is said to have been watered by the *Pison*, the *Gihon*, the *Hiddekel*, and the *Euphrates*. But Josephus, Jerome and Eusebius, tell us that the River *Pison* was called by the Greeks Ganges. Gasinius would have us believe that the *Gihon* was the Nile, and others that it was the Araxes. Malte Brun states, that in the Midian language the *Hiddekel* was called *Tigr*, which is evidently the Tigress. As for the fourth river of Eden, it is expressly identified with the Euphrates, which, like the Tigris and the Araxes, has its origin in the mountains of Armenia. Thus it would appear, that the Garden of Eden embraced the whole of India, Persia, Arabia, Turkey in Asia, and Syria.

It is true that we are not required by the authority of Genesis to believe that all mankind are descended from a single pair, since we read that after murdering his brother Abel, Cain fled to the land of Nod, where he took to himself a wife. Nor is it philosophical to *assume*, as many writers have done, that they are descended from several distinct aboriginal pairs, without positive proof that such has been the case. The opinion of Linnæus, that all the varieties of plants and animals of each species came from one stock, although not proved, is more rational than the late hypothesis of Decandolle, who refers all the known varieties of plants to about twenty geographical centres, from which they have spread and multiplied. But that they owe their specific character chiefly to difference of climate, in the large sense, including soil and other physical conditions favourable to their pro-

duction and development, would plainly appear from the fact, that the plants at different heights, on ascending tropical mountains, exhibit generic and specific differences corresponding with what has been found on advancing from the equator to the higher latitudes, until we arrive at the polar regions. Now if all the various species, amounting to about 100,000, have emanated from a few botanical provinces, why are the plants at the foot of Mount Ararat like those of western Asia; a little higher up like those of Italy; still higher, like those of France; at a greater elevation, like those of Sweden; and beyond this point exhibit the Flora of Lapland? Above all, why have the plants and animals of the same latitudes and provinces been so totally unlike at different geological epochs?

That all the different nations, tribes and families of mankind belong to the same genus and species, is now universally admitted by physiologists. And that they have all descended from the same primitive stock, which began its existence in some part of southern Asia, is maintained by the learned Dr. Prichard, in his work on the *Physical History of Man.* But he thinks that cultivation, or civilization, has had more influence in producing varieties than climate, geographical position, or any other known cause. (*Pages* 155, 194–222, 1st ed.)

The late Godfrey Higgins maintains, in his very elaborate work on the *Origin of Nations, Languages and Religions,* that southern Asia was the ancient mother of nations,—that men gradually spread themselves from India and Arabia, across the Red Sea to Ethiopia, whence they descended the Nile to Lower Egypt, and

from north Africa to other portions of the continent; that from the Peninsula of Malacca they passed over to Sumatra, Borneo, New Guinea, New Holland, New Zealand and other islands of the southern Pacific; that from the north of India and Persia they extended over ancient Scythia, Siberia and the north of Europe; while to the westward, they spread over Asia Minor, Greece, Italy, Spain, Gaul, Britain, Germany and every part of Europe; that the ancient *Sascæ* or Saxons, who occupied the greater part of Europe, were in fact Scythians, that came originally from the north of India and Persia; finally, that the Saxons, Celts and Scandinavians, were successive swarms of the same hive, sent out from middle Asia, and arrived in the west at different periods, like the colonies sent from Great Britain to America, Africa and Australia; the difference in their dialects being such as would naturally arise in a few hundred years in unwritten, or even in written languages. (*Anacalypsis.*)

Dr. Prichard also states on the authority of Herodotus and Diodorus, that the Saxons were Scythians, who were originally a colony of Medes; and that the Tartars of middle Asia, like the Getæ, Thracians, Goths and Sarmatians of northern Europe, were descended from the same stock. He further observes, that between all the native dialects of north Africa there is a close affinity; that accurate observations on the language and customs of the various tribes scattered over the South Sea Islands, put it beyond a doubt, that they all descended from one stock, and came originally from southern Asia; but that owing to their having migrated at very early periods, before

the language and institutions of the mother country were fully formed, few remains of its ancient mythology, manners and customs, have been found among them; and that notwithstanding the difference between the languages of China, India and Egypt, Sir William Jones has traced many striking affinities in their ancient civil and religious observances. (*Op. cit.* pp. 147, 478, 484, 500, 544.)

Dr. Prichard further states, that the primitive language of Persia, called the Zend, was only a dialect of the ancient Sanskrit, from which all the modern languages of India are derived, and differed but slightly from that of Egypt, Phœnicia and Judea,—that the present Brahmans of Benares still perform the same religious ceremonies which were practised in ancient Persia, whose dominion was established over a large portion of Asia, as early as the time of Abraham, and before the extension of the Syrian power,—that the modern Parsees, who are descendants of the ancient Persians, still retain the Zend and Pahlavi dialects; that according to an old poet of Sidon, the founder of Babylon was a Phœnician; and that the same astronomical formulæ were employed in Chaldea as in Egypt. (*Id.* pp. 450, 469.)*

* Lucian also represents philosophy as having commenced in India, whence she repaired to Ethiopia, thence to the Egyptians, and next to the Chaldeans. (*Tooke's Lucian*, vol. i. p. 606.) In accordance with this statement, which is corroborated by Diodorus, Godfrey Huder maintains, that the Egyptians were a people of southern Asia, who travelled westward over the Red Sea, and from Ethiopia, by degrees spread themselves over Upper Egypt. (*Philosophy of Heat.*)

Sir Edward Bulwer justly observes, that "when history fails in accounting for the foreign extraction of any people, or when it is manifestly mistaken, the question must be determined by the analogy of languages, which is at once conclusive, if nothing else were left." And it has been shown by Godfrey Higgins, that *there is not one written language, in which several words of every other written language may not be found;* that according to Vans Kenedy, 900 Sanskrit words have been discovered in the Persian, Greek, Latin, German and English languages; 339 in the Greek; 319 in the Latin; 263 in the Persian; 163 in the German; and 31 common to them all; that according to Cluverius, nearly 1000 Hebrew words have been found in other languages; that Dr. Geddes has shown nearly all the genuine Saxon words to be either Hebrew, Chaldee, Arabic or Persian; that Sir William Drummond has traced a radical affinity between the Coptic or Egyptian, the Ethiopic, the Chaldee, Arabic and Hebrew; that General Vallancy has shown the ancient Celtic to be a dialect of the Phœnician, which Le Clerc, Gesenius and others, have proved to be nearly identical with Hebrew, and closely allied to the Sanskrit and Zend, from which the ancient Scythian, Manchoo Tartar, German and Celtic are derived, as the Italian, French and Spanish, from Latin; that Vallancy further asserts, that almost every word in the first twelve verses of the Illiad may be traced back to Phœnician, Egyptian, Chaldee and Hebrew origin; and that in the native Irish language, which is Celtic, he found fifty words relating to augury and divination, every one of which was oriental. (*Anacalypsis*, vol. i.

pp. 449, 454 and 461.) Von Hammer says, that there are remarkable affinities between 400 German and Persian words. (*Archis*, p. 126.)

Corresponding with the foregoing facts, we are informed by Jacob Bryant, in his very learned work on *Heathen Mythology*, that the Greek words ζωη, life, ζωον, an animal, and ζωειν, to live, were derived from *zoon* or *zoan*, a Phœnician and Egyptian name of the sun,—showing that in the earliest times, the Greeks regarded life as an emanation from that luminary, as maintained by Macrobius in the third book of his *Saturnalia*, (page 282.) And Wilkinson states in his late work on Egypt, that *onh* is still the Coptic word for life, the male principle of which was termed *linga*, and the female *yoni*, as in ancient India, where the genetic power of solar heat was represented by the male and female organs of generation. (*Page* 523, 1st ed.) Bryant has further shown, that the Greek word Αιθερ, *Aither*, was derived from the word *Aith*, *Ath*, *Eth* or *Oth*, (all of which are modifications of the same word, signifying the sun, among the Egyptians, Phœnicians and several other oriental nations,) and from *Aur*, *Our* or *Ur*, meaning light or fire; and when joined together, signifying solar light or fire. But both of these words are also Hebrew; and Dr. Adam Clarke says, in his Commentaries on the First Chapter of Genesis, that אות, *Ath*, *Eth* or *Oth*,* signifies the

* Bryant maintains that the Greek word Θεος, was derived from the Egyptian *Thoth*, which is doubtless a modification of the Hebrew and Phœnician *Oth*, the sun,—"on which the young nations of the world gazed with the freshness of childhood, until their admiration became a worship,—wondrous and divine still, after all

sun, the lights of heaven, and the substance of all things; while the word אור, *Aur*, *Our* or *Ur*, designates light, fire, lightning, and sometimes the rainbow. Parkhurst also observes, that *Aur* denotes the extreme fluidity of light, or the continual flowing of its particles from the sun, which in the Twenty-fourth Psalm is termed the king of glory,—a word that plainly implies the action of light; that in the thirty-first chapter of Job, *Aur*† is employed to signify the sun; and fire in the Book of Ezekiel, as in many other parts of the Old Testament.

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our Astronomies and Almanacs." (*Carlyle's Hero Worship.*) Bryant further states, that *Bel*, *Bal* or *Baal*, was a Babylonian title of the sun, and when compounded with *Orus*, as in *Bel-Orus*, signified the Lord of Light. Dr. Prichard also observes, that *Sunuh* was one of the Sanskrit names of the sun, which in the Manchoo Tartar language is *Shun*, and *Sonne* in German. The Latin verb *uro*, I burn, is also derived from *ur*, fire.

† He further states, on the authority of Varro, that the Latin word *aurum*, was derived from *Aur*, meaning the golden sun, with his heavenly light. Nor is it less certain, that the Greek word Αηρ, and the Latin *aura*, signifying air, were derived from the same Hebrew and Phœnician root; that the spirit termed רוח, described as moving *on the face of the waters*, and as *breathed into the nostrils of man*, like the *Πνευμα*, the ψυχη, and Ανεμος of the Greeks, literally means breath, the *air in motion*, and *animal life;* that there is not a single word in the Old or New Testament, nor in any written language, to designate the human soul, or any spiritual essence, which does not also signify air, light or fire. But from the time of Orpheus to that of Hippocrates, and even down to the period of Cicero, the Greeks and Romans confounded air, (because ignorant of its compound nature, and of the limited extent of the atmosphere,) with the more subtile and all-pervading ether, which they were fully aware extended throughout universal space. Hence the assertion of Aristotle, that nature abhors a vacuum, which, he very truly observes, would destroy all motion.

Bryant has also shown that the Greek word Ἑλιος, or *Helios*, is radically identical with the Phœnician word *Elion*, a compound of *El* or *Eli*, and *On;* both of which were primitive titles of the sun, and signified *Deus Sol.* With Macrobius, he maintains that all the Grecian names of Deities were originally titles of one God, and related to the sun or solar fire; that from the names of places, mountains, groves, fountains, *mounds, towers, temples* and *obelisks*, consecrated to the sun, and called after him, the Greeks invented ideal gods, heroes, and the histories of what they had done,—that the name of Persia was taken from *Parez* or *Perez*, an eastern name of the sun,—that Syria was derived from *Sur* or *Suria*, a Chaldean title of the sun, which is also termed *Surya* in Sanskrit,—that Ethiopia was formerly called Atheria, from *Ath* and *Ur*, or from *Aythur*, meaning land of the solar fire; that the Greeks took their appellation of Ἑλληνες, *Hellenes* or *Heliadæ*, from *Helios*, implying their descent from the solar race. (*Heathen Mythology*, vol. i. pp. 56, 96; vol. ii. p. 405.)

Dr. Prichard also informs us, that one of the Sanskrit names of the sun is *Hailigh* or *Hailis*, Col. Melford says *He-li*, (*Asiat. B.* vol. iii. p. 460,) and is doubtless the same word as *Helios* or *Helion*,—which is one of the titles employed in the Hebrew Bible to designate the Supreme Deity, according to the very learned Jerome, who is represented by Parkhurst as the most skilful Hebracian among the Fathers. Another title of the Supreme Creator in Hebrew is *Adonai*, which, according to Bryant, is compounded of three Phœnician words, *Ad*, *On* and *Ai*,—all of which designated

the sun, who was worshipped as the creative and formative God in ancient Tyre, Sidon, Canaan and Carthage. Another and still more common title of the Supreme Deity in Hebrew, is the word אל, *Al*, *El*, *Eli*, or *Elion*,—all of which are modifications of the same word, which we have already seen was a Phœnician, Sanskrit and Greek name of the sun. We also read in the first chapter of Genesis, that in the beginning, אלים, *Elohim*, created the heavens and the earth.

The ablest Hebrew scholars differ in opinion as to whether the word *Elohim* is singular or plural, as it sometimes agrees with singular, and at other times with plural verbs. But Parkhurst maintains, that it generally answers to the Greek word *Θεος*, and expresses the universal extension or omnipresence of the Divine spiritual essence,—moreover, that the idea of this attribute was taken from the celestial fluid in its threefold condition of *light*, *fire* and *spirit*, operating jointly in every effect. He also quotes the declaration of Diodorus and Varro, that the Egyptian *Jove* was identical with the *Jehovah* of the Jews,—that with some dialectical variations, the Phœnicians, Etruscans, Romans and other ancient nations, gave the same title to the all-pervading fiery *Ether* that was supposed to actuate the universe, and to endow all beings with life. He further states, on the authority of Servius, that the Deity was termed *Al* or *El* in the Phœnician language,—and that the Canaanites had a tower or temple dedicated to the sun, אל, *Al*, according to Josephus. (*Hebrew Lexicon.*)

In accordance with these remarkable analogies, it is

stated by Godfrey Higgins, that the root יהוה *Yeye* or *Yehovah*, signifies, in both Hebrew and Sanskrit, *to be, to live*, and the *self-existent fire*, which, under that sacred title, the Brahmans chaunted in their service. (*Anacalypsis*, vol. i. pp. 430, 468; and vol. ii. p. 249.)

Nor is it surprising that the language, and many of the Jewish customs, so nearly resembled those of several oriental nations, when we reflect, that Abraham was a Chaldean,—that his descendants resided long in Egypt, during which time they must have adopted the language, manners and opinions of that country; that from Egypt they removed to the Phœnician land of Canaan, where they very soon adopted the worship of *Baal* and *Molech*,—which was practised to a greater or less extent, from the time of Joshua until they were carried away captive into Babylon, (from which the ten tribes never returned;) and where they learned the Chaldee letters, in which the Hebrew Bible is written.

Like the ancient Hindoo word *Alkache*, the Arabic name of God, *Allah*, is doubtless a modification of the Hebrew אֵל, *Al*. We are also informed by Diodorus, that among the Egyptians *Jove* was a personification of the *celestial Ether*, which they called *Youpiter*, because the spirit of life, and the generator of all things, according to a priest of Memphis,—and that the Greeks derived their word ζεω, to burn, from his name, Zeus. (Lib. i.) And Servius states, that natural philosophers will have *Jupiter* mean the *Ether*, whence he is called Ζευς, from ζειν, to be hot or warm. (*Æneid* i.) Similar expressions are found in Euripides, who represents the unbounded *Ether* which encircles all things

as *Jove.* The Roman poet, Ennius, also says, that all invoke the shining Ether as *Jove.* And Virgil calls him *Pater Omnipotens ÆTHER.* (*Georg.* ii. line 325.)

Sasenius tells us, that the Hebrew language was nearly the same as that of the Phœnicians in Canaan, until the Babylonish captivity, when the Jews adopted the Chaldaic, which is closely allied to the Egyptian, the Sanskrit, and all the most ancient languages of Asia.

Plutarch further states, that *Osiris,* an Egyptian name of the sun, signified likewise the *Ether* or active principle in nature, and *Isis* the passive elements from which everything is formed. Macrobius also maintained, that there exists a luminous, igneous and subtile fluid, which, under the name of *Ether* or *spirit,* fills the universe; that it is the essential principle of motion and life; and is, in fact, the Deity. (*Somn. Scip.*) The same doctrine was held by the learned Varro, who regarded the Ether as the essence of Deity, according to St. Austin. (*Civitas Dei,* lib. vii. c. 22.)

The truth is, that the worship of the sun, or of that etherial fire which animates the *infinitude* of suns which glitter in the boundless firmament, was practised in Memphis and Thebes, Nineveh and Babylon, Tyre and Sidon, Balbec and Jerusalem, long before the time of Abraham; that it prevailed from Ethiopia to Siberia, and from Eastern Asia to the remotest borders of Western Europe, if not in every part of the inhabited world,—for it may be traced in the language, mythology and monuments of North and South America. Temples dedicated to the sun have been discovered in the ruins of Palenque and other ancient

cities of Central America. We also learn from Robertson's *History of America*, that the Iroquois, Hurons, Algonquins, Natchez and many other Indian tribes, performed the religious ceremony of dancing around what they called the *holy fire*, into which they cast a portion of everything they used, as a sacrifice in honour of the sun. (Vol. ii., book iv. p. 23.)

The same fact is attested by Adair and many other travellers. Mr. George Catlin also states, that the Mandans of the Upper Missouri "offered sacrifices, prayers and thanksgivings to the *Great Spirit who lives in the sun*,"*—that they had a tradition concerning the transgression of the first woman, the general deluge, the miraculous conception, birth, subsequent miracles, and death of a Saviour. (*Manners, Customs, etc. of the North American Indians*, vol. i. p. 180; vol. ii. p. 135.)

We are further informed by Lord Kingsborough, that the native language of Mexico, (like the Saxon and Celtic of Europe,) is full of Hebrew words; that the people had a tradition of the flood, performed the rites of circumcision, baptism and auricular confession,

* There is reason to believe that the pyramids of Egypt, the turrets of China, the cromlechs of the Druids, the round towers of Ireland, and the mounds of America, were originally intended as monuments of the same primitive worship practised in groves and high places by the Canaanites and all the ancient nations of the earth. For it is stated by Parkhurst, on the authority of several distinguished authors, that obelisks were originally dedicated to the sun. And Volney says, that the Egyptians represented the sun by a cone, fire by pyramids, and the earth by a revolving cylinder. Nor is the opinion that the pyramids were consecrated to the worship of fire inconsistent with the general belief, that the kings of Egypt were buried in their vaults.

sacrificed their first-born, like the ancient Phœnicians, Syrians and other oriental nations, including the early Jews; and that they expected a Messiah. (*Antiquities of Mexico*, vol. vi.)*

It is also stated by Higgins, on the authority of De Guignés, Bergeron and Paravey, that an ancient Chinese History, called the *Chan King*, treats of the terrestrial paradise, the fall of angels and of man, the Sabbath, confusion of tongues, manna in the wilderness, the Trinity, and of the Holy One in the west, who was incomprehensible, and one with *Tien*, for whom the nations of the earth are waiting like plants for a refreshing shower, as taught by Confucius nearly twenty-four hundred years ago. (*Op. cit.* vol. ii. pp. 28, 33.)

Thus it would appear from the language, traditions and monuments of America, that it was originally peopled from the Asiatic continent. In opposition to this view, we are told by Voltaire, that the same creative Power which caused grass and trees to grow on the American soil, could place man there. Dr. Prichard and Mr. Lawrence also admit, with Buffon, that, excepting the regions north of the Baltic in the old world, and those north of Canada in the new, no quadrupeds were originally common to both. But the ab-

* In eighty-three American languages, examined by Barton and Vater, one hundred and seventy words were found, the roots of which appear to be the same. Of these one hundred and seventy, three-fifths resemble the Manchou, the Tonguse, the Mougol and the Samayed; and two-fifths the Celtic and Tchoud, the Biscayan, the Coptic and Congo languages. (*Humboldt's Views of the Cordilleras*, English translation, vol. i. p. 19.)

sence of the horse, ox, sheep, dog, and other domestic animals of the old world, in the greater part of the American continent when first discovered by Columbus, tends rather to prove that the new world was elevated from beneath the ocean at a more recent geological epoch, than Asia, Africa or Europe,—an hypothesis which is corroborated by the great number of volcanos and earthquakes now in operation in various parts of South America, Mexico and the West Indies. It is also well known that large districts in Chili, Mexico, and other parts of the country, have been raised several feet within the last few years. And Darwin, the naturalist, says, that they are covered with the same species of shells that now inhabit the Pacific. But as if the recent origin of a continent were a proof of inferiority, Dr. Caldwell rejects the hypothesis as "a calumnious fabrication, invented for the purpose of depreciating the new world."

Others have maintained, that if America had been peopled from Asia, the natives would not have been ignorant of letters and the use of iron. But, as Higgins observes, this may have been owing to their separation from the primitive tribes of the old world, before they had advanced beyond the savage or pastoral state. And he thinks that, as the horse was unknown in America previous to the time of its discovery by Columbus, the pictorial representations of that animal by the Mexicans, prove that their progenitors came originally from the old world.

If, then, it be true, that Africa, New Holland and the various islands of the Pacific were peopled from southern Asia, which, as we have seen, was the seat

of the Garden of Eden,—that ancient Scythia, northern Asia, the whole of Europe, and the new world, were peopled from the same prolific region,—there is no foundation in nature for the division of mankind into three, five or more primitive races. We are therefore authorized to conclude, that all the nations, tribes and families of the earth are descended from one and the same original stock—in other words, that "God hath made of one blood all the nations that dwell on the earth." Nor will the admission of five or more primitive races explain the endless varieties of colour, form, etc. of the human species,—why, for example, the Patagonians are so different from the natives of Terra del Fuego on the one hand, and those of Peru, Brazil, Guiana and Mexico on the other,—why the Osage and Black Feet Indians are larger than any other tribes of North America, and the Esquimaux little above the stature of dwarfs; while they are all supposed to belong to one and the same distinct race. Again, there is a far greater difference between the tribes of northern Asia, Europe, or even of Tartary, and the natives of China, (all of whom are regarded as belonging to the Mongolian race,) than between the latter and the Hindoos, Arabs, Egyptians, Persians, Georgians and Circassians, who are equally different from the Greeks, Romans, Germans, Dutch, British and other nations of Europe—all of whom are supposed to have descended from the Caucasian stock. There is also an endless diversity among the tribes which constitute the negro and Malay races, as they are called. Among all the various classifications of mankind that have been offered, the most singular is

that of Oken :—1. *Homo cuticularis,* the Ethiopian; 2. *Homo lingualis,* the Malay; 3. *Homo nasalis,* the American; 4. *Homo auricularis,* the Mongolian; 5. *Homo ocularis,* the Caucasian or European.

Having in the preceding chapter examined the influence of climate on the stature, magnitude of the chest, size and form of the head, intellectual and moral character of the human race, I proceed to inquire how far it modifies the complexions of mankind. Dr. Prichard states, on the authority of Herodotus, Diodorus, the travels of Norden, Volney, Sonnini and Denon, that the original colour and general configuration of the ancient Egyptians were those of the negro race, with dark skin, woolly hair, prominent cheek-bones, low and narrow forehead, thick lips, flat nose, protruding eyeballs and short stature.* In support of this opinion, Godfrey Higgins states, that the most ancient statues of India and Egypt are black, with curly hair, thick lips and flat nose; that in Greece, which was originally peopled from southern Asia and northern Africa, the statues of Jupiter, Hercules, Bacchus and other gods, were of the same colour,—from which he inferred, that all the first inhabitants of the earth were black, and gradually changed through every gradation of colour, on spreading over the higher latitudes.

Yet Dr. Prichard thinks that "climates have very

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* Dr. Latham, in his recent work on the *Varieties of Men,* says of the modern Copts, who are descended from the ancient Egyptians, that the hair is black and crisp, or curled, the cheek-bones projecting, lips thick, nose somewhat depressed, nostrils wide, complexion varied, from yellow to dark-brown, eyes oblique, physiognomy heavy and inexpressive. (*Page* 509.)

inconsiderable and doubtful effect in exciting varieties of complexion,"—which are owing more to civilization or "cultivation, than to any other known cause." (*Physical History of Man*, pp. 155, 194, 222.) But it is only in the hottest portions of the earth that man is perfectly black, as among the negroes of Soudan, Bennin, Dahomy, Loango, Angola, Benguela, and other parts of central Africa. In fact, the genuine negroes of Africa are confined chiefly to the low lands and river-courses, such as the valleys of the Senegal, the Gambia, Niger and Upper Nile. If we pass to the more temperate regions of north and south Africa, we shall find that the natives are neither black nor white, but exhibit various shades of colour, from dark-brown, olive and dusky-red to a tawny-yellow, with black and slightly curled hair, as among the Berbers, Caffres, Boshuanas, Hottentots and several other tribes.

We have also seen, that in the tropical portions of New Holland, the temperature approximates that of central Africa, owing to the absence of mountains, the prevalence of large sandy deserts and the scarcity of rain,—that in this dreary region the mercury sometimes rises to 112° in the shade, during the hot winds from the interior, according to Mr. Lang—and it is known that the natives are almost as black as in central Africa. The climate is also excessively hot in the large tropical islands of New Guinea, Borneo, Java and Sumatra, in consequence of their vicinity to southern Asia and New Holland. As might be supposed, the natives exhibit various shades of black, dark-brown and dusky-olive. But among all the smaller tropical islands scattered over the Pacific, where the temperature

scarcely ever rises above 85° or 90° in the shade, there is not one that contains a purely black population. Although continually exposed to the sun, the natives are of a light-brown complexion, with long, straight hair, regular features and fine symmetrical forms, especially on mountainous islands, where the inhabitants are larger and fairer than on such as are low and level, according to the observations of Captain Beechy and others.

Moreover, it is well established, that the inhabitants of southern India, China and Arabia, are several shades darker than in the northern portions of those countries; and more dark than the Japanese, who live in a more temperate climate. We also learn from Niebuhr, De Pages and Frazer, that in the burning province of Yemen, or Desert of Akhaf, the Arabs are of a colour approaching that of the negro, and have curly hair. But Bruce states, that among the mountains of Ruddua in the north of Arabia, where water freezes, the natives have red hair, blue eyes and fair skin. Nor is it less certain, that the Persians and Turks are darker than the Georgians and Circassians; that in the north of Spain, Italy, and even France, the inhabitants are much fairer than in the southern provinces; finally, that in England, Scotland, Ireland, Belgium, Holland, Germany, Sweden, Denmark and Russia, where the mean temperature of summer is lower than in any other part of the world in corresponding latitudes, and varies from 60° to 66°, they are of a ruddy white complexion, with fair hair and blue eyes, modified, however, by more or less exposure to the sun, and by mixture with the natives of other climates, which produce an endless variety of shades.

But why should I multiply words to prove that the sun, with his different coloured rays, is the great Painter of Nature? For *no indigenous white race has ever been found within the tropics, and no black nations in the middle or higher latitudes*, if we except the dark-brown inhabitants of Van Dieman's Land, who, as Dr. Prichard observes, may have come from New Guinea, the tropical portion of New Holland, or some other hot climate.* Is it not also an incontrovertible fact, that Europeans become several shades darker, and often quite brown, after residing fifteen or twenty years in tropical India or South America? Nor is this any more remarkable than that the blush of the apple, peach and other fruits, should be always deepest on the side exposed to the sun,—that the sky, the ocean, the evening clouds, the plumage of birds and insects, with all the adornments of the external world, should be always most richly and variously coloured where the power of the sun is greatest; and diminish on to the polar regions, where they are reduced to a dull monotonous mixture of brown and leaden gray in summer, and to whiteness during winter,—that those parts of animals from which the solar rays have been excluded, are pale or white, like celery and other plants when kept in the dark,—or that the offspring of brown mice when constantly kept in dark cellars, is often white, with reddish eyes. It is said that in

* Dr. Latham very justly observes, that migration from a tropical continent to tropical islands, would favour a gradual change from dark to fair, while the transition from the latter to New Guinea and Australia, would produce a change from fair to dark. (*Varieties of Man*, p. 259.)

southern Italy, sheep and swine are chiefly black; whereas in England, their prevailing hue is white. (*Wiseman's Lectures*, vol. i. p. 190.)

Should it be asked why the natives of tropical America are less dark than those of central Africa, southern India, New Holland, New Guinea, Borneo and Sumatra, I answer, that the mean temperature of South America is greatly mitigated by the continual exposure of its eastern coast to the trade-winds,—by the elevation of Chili, Peru and Mexico, from eight or ten to thirteen thousand feet above the ocean,—and by the small amount of dry land between lat. 10° and 30° N.; giving to Guatemala and Mexico the character of a maritime climate. Accordingly, we are informed by Bougouer and other travellers, that on the table-lands of Peru the natives are much fairer than on the low and level plains of Brazil, where, Dr. Prichard says, they are nearly as black as Africans. Don Antonio D'Ulloa says, the natives of Guayaquil, in Peru, are fresh coloured, and fairer than the Spaniards. (*Voyage to South America*, vol. i. p. 171.) We also learn from the surgeon who accompanied Captain Beechy in his voyage of discovery in the Pacific, that among the Araucoans who inhabit the temperate climate of Chili, he found several individuals that had gray eyes, which is never the case with persons of dark bronze or copper complexion. Molina also describes those who inhabit the thirty-ninth degree of south latitude, as fair and well-featured as the northern Europeans.

It has been stated on the authority of Humboldt, that the colour of the native Americans is nearly the same in all latitudes; consequently that difference of

climate will not explain all the varieties of complexion in the human species. But this assertion is refuted by the testimony of numerous accurate observers. Humboldt himself states, that the Indians of the upper Orinoco are fair; and that on the northwestern coast of America, around Cloak Bay, in lat. 54°, the natives have large eyes, European features, and are not darker than the peasantry of Germany. It is also stated by Say, Major Long and other travellers, that near the sources of the Mississippi, the natives are much fairer than the more southern tribes of North America; and that many individuals have light flaxen or yellow hair. Mr. Catlin further states, that among the Mandans who resided in lat. 46° N. and had become so far civilized as to have comfortable dwellings, with the art of manufacturing vessels of pottery, there were females almost white, with hazel, blue and gray eyes, regular features, and hair of every colour, except red and auburn. (*Manners, Customs and Condition of the North American Indians*, vol. i. p. 94.) Even among the Esquimaux, Charlevoix observed individuals with red hair. And Dr. Morton admits that the aboriginal Americans exhibit all the varieties of colour, from a decided white to an unequivocally black skin. (*Cran. Americana*, p. 69.) Certain it is, that the people who inhabit the high table-lands of Mexico are much fairer than those of Vera Cruz and other towns on the coast.

Should it still be urged, that the general complexion of the native Americans is that of iron-rust, while that of the various tribes in northern Asia and Europe is yellow or tawny, it may be answered, that all barbarous nations are continually exposed to the sun and

air during summer, and mostly confined in smoky dwellings amidst filth during winter, while many of them employ red paints. But it is obvious, that if the whitest nations of Europe had been exposed in the same manner for a sufficient length of time, their skin would be thick, coarse and yellow, the hair and eyes black. For the peasantry of Switzerland, Germany, France, Poland, Sweden and Russia, are of a brownish-yellow colour, and several degrees darker than the inhabitants who remain chiefly within doors during the heat of the day.

In support of his theory, that civilization, or what he calls "cultivation, produces greater varieties of complexion than any other known cause," Dr. Prichard says, that the Moorish ladies of north Africa, who remain in the shade, are often beautifully fair; while their brothers, who are much exposed to the sun, are brown or olive; that the Brahmans of India, (which is equally true of the wealthier classes in general, including the Parsees,) are several shades lighter than the field labourers, boatmen and sailors; that the Tartars who conquered China about two centuries ago, and adopted the habits of civilization, have become much fairer, and now often have blue eyes. But Dr. Prichard seems to have overlooked the fact, that in warm climates, the temperature is 20° or 30° higher in the sun than in the shade,—a difference almost equal to that between the tropical and middle latitudes,—*so that what he calls cultivation means protection from the influence of external temperature, which is the principal element of climate.* He admits, that the Kabyles of Tunis and some of the high mountains in

north Africa, (where the climate resembles that of Greece and Italy,) are of a fair and ruddy complexion, with hair of a yellow or reddish colour, as stated by Shaw, Hornemann and Marsden,—while the Tuarics of the Great Desert, who speak a dialect of the same language, are of a dark-brown complexion, as among the natives of Ceylon, Bengal, Malacca, Penang, Madagascar and other tropical climates. Should it still be objected that the inhabitants of northern China are darker than those of western Europe, where the mean annual temperature is nearly the same, I reply, that the average of summer is from 15° to 20° higher at Pekin than in Great Britain, France, Germany and Holland, the natives of which are much fairer than in Italy, Greece, Spain and Portugal, where the climate is proportionally warmer.*

Dr. Prichard maintains, that "the complexion acquired by exposure to the sun is not imparted by parents to their offspring,—and that no change of climate, however great, or for whatever time its influence may have been exerted, could transform white Europeans into negroes, or even make them approximate in any considerable degree." (*Op. cit.* pp. 194, 222.) The same opinion has been embraced by Mr. Lawrence. And Dr. Caldwell maintains, that although

* In fact, we are assured by the Rev. Samuel Stanhope Smith, that "in no other country is there such a regular gradation of colours as is traced from the fair natives of Pekin to the inhabitants of Canton, who are of a dark copper." (*Variety Hum. Spec.* p. 76.) He might have added, that in western Asia, the colour deepens from Persia, where the people are fair, to the south of Arabia, where they are nearly black.

the whites in Africa have been somewhat darkened, their constitutions deteriorated, and their numbers reduced, no perceptible progress, or even tendency, has been made toward their conversion into another race. Nor does he believe that the negro owes his colour to a tropical sun, because those parts of the body which are covered with us, are of the deepest black. But he forgets that in Africa, the natives generally go naked, or nearly so, as among all barbarous tribes in warm climates. On the coast of Guinea and other parts of tropical Africa, most of the lower animals, such as cattle, dogs and poultry, like men, were black. (*Voyage to and from Borneo*, 1712, p. 14.)

In opposition to the foregoing views, we are informed by Herder, on the authority of highly respectable travellers in Africa, that the descendants of the Portuguese who settled on the coast of Guinea about three hundred and fifty years ago, are nearly as black as the natives; while in symmetry of form, regularity of features, and general intelligence, they have signally degenerated. (*Philosophy of Hist.* vol. i. p. 267.) And Bishop Heber says, that the Portuguese of India have become black as Caffres. (*Narrative*, vol. i. p. 68.) Finally, Dr. Morton says, "that the Foulah or Fellatah population of central Africa, now spread over a region of 1500 miles from east to west, and 500 miles from north to south, are a mixed progeny of Arabs, Berbers and negroes, no longer admits of a reasonable doubt."

If, then, there has been so great an approximation of Europeans to the colour and other peculiarities of the negro race in three hundred and fifty years, what

changes might naturally be expected to arise in the course of two or three thousand years? Does this not look as if the white might be transformed gradually into the black race? In support of this opinion, Bruce states, that the Jews are black in Abyssinia, brown in Arabia, Syria and Egypt; and it is certain that they are much darker in Italy, Spain, Portugal, Greece and Turkey, than in Britain, France, Holland, Germany, Sweden and Russia, where many of them are exceedingly fair and ruddy, with sandy beards.

We also learn from *The Researches* of Claudius Buchanan in India, that before the downfall of the Babylonian empire, a colony of Jews settled in the southern province of Malabar, who are now black, and scarcely distinguishable from the Hindoos; whereas the modern Jews who came from Palestine at a much later period are nearly white. (*Pages* 226–230.) Malte Brun further states on the authority of Oldendorp, that Loango, in tropical Africa, contains black Jews scattered throughout the country. (*Histoire de la Mission*, p. 287.) It is therefore undeniable, that notwithstanding the rigid adherence of this remarkable nation to their original manners, customs and modes of living, their complexion is as various as the climates in which they have long resided. Burkhardt says, that the descendants of Arabs and Turks who were sent by Selim, after his conquest of Egypt, to the African coast of the Red Sea, are of the darkest brown, approaching to black. (*Travels in Nubia*, p. 391, second edition.) Various other travellers affirm, that the Arabs who passed over to Africa about a thousand years ago, are much darker than those of Asia; and

that in the Great Desert of Sahara, they have become nearly as black as the Tibboos and natives of Fezzan.

There is also reason to believe, that in the course of two thousand years, and perhaps a much shorter time, the blackest negroes of central Africa would become perfectly white in such a climate as that of Great Britain, and undergo a corresponding change in their whole organization. For it has been observed that, after the third generation, the descendants of negroes brought from Africa to the United States, are several shades lighter than their ancestors,—the hair longer, softer and less curly; the eyes more animated, the mouth smaller, the nose more elevated, and all the features more agreeable, with a corresponding improvement of the intellectual faculties,—the change being much greater among domestic servants than field labourers, who are more exposed to the sun. (*Smith on the Causes of Variety of Complexion and Figure in the Human Species*, pp. 115, 171, second edition.) I have also been informed by a highly intelligent gentleman of colour from St. Domingo, that he has observed a considerable change of his own complexion, and that of his countrymen in general, after a few years residence in Paris or London.

From all the foregoing facts, we are authorized to conclude:—

1. That if the climate of the whole earth had been the same as that of tropical Africa near the level of the sea, ever since the origin of mankind, they would have been everywhere black, with curly hair and dark eyes.

2. That as the Greeks and Romans, Saxons and

Celts, came from southern Asia and northern Africa, they must have originally been of the same complexion and configuration as the present Hindoos, Egyptians and Moors, who are of a dark-brown colour.

3. That if in all latitudes, the temperature of the earth had always corresponded with that of Britain, France, Germany and Holland, there would have been no black nor brown nations and tribes.

4. But that as the temperature of the globe is diversified by the inclination of its axis, the unequal distribution of land and sea, mountains and valleys, dense forests and sandy plains, there is a corresponding variety of colour, form, features and whole organization of the human species,—multiplied by the mixture of nations, tribes and families, by conquests, migrations and intermarriages.

The truth is, that if caloric be the organizing principle throughout nature, it must determine all the various degrees and modes of action, on which every diversity in the structure of plants and animals depends,—that as all the organs are formed by the nutritive process, the rapidity of which is in proportion to the amount of respiration, they are more fully developed in warm than in cold-blooded animals, modified, however, by climate, or external temperature, nature of the surrounding medium, and the various circumstances which tend to augment the growth of some one or more organs, and to suppress that of others, as shown by the numerous diversities of form, size, intelligence, &c. among animals belonging to the same genus and species.

Moreover, it has been ascertained by the researches

of Lamarck, St. Hilaire and other eminent physiologists of France, whose views have been adopted by Dr. Grant, that all the animals enumerated by naturalists (amounting to about 557,600 species) have been formed after one and the same primitive type or model,—the lower orders differing from the highest chiefly by defect,—in other words, *that all the animals which inhabit the earth are, in reality, but one animal*, as maintained by Aristotle. The unity of organization has been still further traced by physiologists, who have found that in plants, the primitive tissues from which all the others are evolved, consist of nucleated cells, essentially analogous to those that constitute the elementary tissue of the ovum in all animals. (See *Owen's Lectures on Reproduction*, in the *Lancet* of 1841.)

And that there has been a gradually ascending progress of organization, would appear from the recent discoveries of geologists, who have found that the oldest sedimentary formations are filled with animals of the lowest class and most simple structure, which becomes more and more complex, until we arrive at the newer tertiary deposits, which abound with the fossil remains of the higher or warm-blooded species. Yet there is no historical proof that fishes have ever been transformed into reptiles, nor the latter into birds and mammalia. Nor is it probable, even if such were the fact, that it will ever be demonstrated otherwise than by analogy—owing to the enormous periods of time, and perhaps the great geological changes, requisite to bring about corresponding changes of organization. In the present imperfect state of our know-

ledge, it must therefore remain a problem, whether the higher orders have arisen by imperceptible degrees from a very simple state during the long course of innumerable ages.

It would doubtless be interesting to know whether, if all the plants and animals that now inhabit the earth were destroyed, similar orders, tribes and families would gradually arise, in obedience to existing laws,—whether the higher orders began their existence in a very simple state, and gradually advanced from one stage of development to another, as the recent discoveries in geology would seem to indicate,—and why it is that among all the higher animals, nearly an equal number of the two sexes were produced. In all these things there is a profundity of wisdom before which we must bow with humility and pious adoration.

But I must now examine briefly the influence of climate on the duration of human life. From the researches of M. Moreau de Jonnés, published in the *Revue Encyclopédique* for 1833, we are enabled to compare the annual mortality of different countries in Europe, as in the following table, constructed from various statistical reports:—

Great Britain .... from	1800 to 1804	1 in 47
Germany proper	1825 to 1828	1 in 45
Sweden and Denmark	1821 to 1825	1 in 45
Russia in Europe	1826 to	1 in 44
Kingdom of Poland	1829 to	1 in 44
Austria	1825 to 1830	1 in 40
Prussia	1821 to 1826	1 in 39
Holland	1827 to 1828	1 in 40
France	1825 to 1827	1 in 39·5
Switzerland	1827 to 1828	1 in 40

Spain ....from	1801 to 1826	1 in 40
Portugal..	1815 to 1819	1 in 40
Italy..	1822 to 1828	1 in 30
Greece	1828 to	1 in 30
Turkey in Europe............................	1828 to	1 in 30

Thus we perceive that, in the temperate and colder latitudes of Europe, life is longer than in the warm climates of Italy, Greece and Turkey, where the temperature of summer approximates that of the tropics; and longer in the equable climate of Great Britain, than in any other part of Europe. For example, it is stated by Mr. Farr that the annual mortality of England and Wales, exclusive of still-born infants, is 2·17 per cent.; while in Sweden it is 2·46, in France 2·52, and in Prussia 2·80. (*Third Report of the Registrar-General*, p. 101.)

In an article on Miasm, by Dr. John Bell, published in the *North American Journal of the Medical Sciences*, the author states, but without giving his reference, that between the 14th and 25th of July, 1743, 11,000 persons fell dead in the streets of Pekin, the population of which is rated at 1,500,000. And, although the temperature of summer is less in the United States than in China, it is well known that the mortality of our large cities is greatly augmented during July and August, especially among labourers in the hot sun, who are often attacked with apoplexy, (*coup de soleil,*) phrenitis, cephalalgia, paralysis, or congestive fever.

The unnecessary waste of life occurring every year in Great Britain has been estimated at 60,000 souls, and the number of cases of sickness which might be prevented at 1,708,000, or, at the lowest calculation, 1,020,000. (*Brit. and For. Medico-Chirurg. Rev.*, Jan.

1848.) But if we estimate the population of Great Britain at 26,000,000, and that of all Europe at 250,000,000, the annual waste of life from diseases which might be prevented, must be 576,923 souls. And there is good reason to believe that this estimate is a moderate one, perhaps very far below the actual truth.

We also learn from the Second Report of the marriages, births, diseases and mortality of England and Wales, that out of a population of 15,666,800 in 1838–9, there were 103 deaths at the age of 100 and upwards; and 140 per 1000 at the age of 70 and upwards. It is much to be regretted that these exceedingly valuable reports have not yet embraced Scotland and Ireland. Nor do they represent, as they ought, the whole number of living individuals who have arrived at 100 years of age and upwards.

But it is stated by Dr. Copland, in a note to *Richerand's Physiology*, that according to authentic returns, the ratio of centenarians in England was ·34 for every 20,000, in a population of 12,218,500 in the year 1821—which would give 207 individuals then alive, who were 100 years old and upwards, or one for every 59,000. He also states, that in Scotland, when the population was 2,135,300, the ratio of centenarians was 1·903 for every 20,000—which would give 203, or one for every 10,484. And he says that in 1811, according to the bills of mortality in Russia, the whole number of deaths was 828,561, of which nine hundred and forty-seven occurred at the age of 100 and upwards; fifty-one at 120; twenty-one at 125; seven at

130; one at 135; and one at 140. But there is reason to doubt the accuracy of this report; for, according to Sir John Sinclair, the number of deaths throughout the empire, at the age of 100 and upwards, was only 436 in the year 1801. (*Code of Health*, vol. i. p. 119.)

The superiority of Great Britain over all other parts of Europe, in health and longevity, would appear from various considerations. Passing over the account of Galour McCrain, of the island of Jura, who is said to have died in the reign of Charles I. at the age of 180, it is tolerably well established, that during the sixteenth and seventeenth centuries, Francis Conciest, of Yorkshire, lived to the age of 150; Thomas Parr, of Shropshire, to 152; and Henry Jenkins, to 169:—that in Scotland, Mr. Lawrence died at the age of 140; Margaret Patton at 138; and John Mount at 136:—that in Ireland, Colonel Winslow died at the age of 146; the Countess of Desmond at 140; and a very large number, in all parts of the United Kingdom, at 120 and upwards. Sharon Turner gives an account of an Irishman of Kerry, who, at the age of eighty-four, had married a young, fifth wife, by whom he had twenty children, and that he died at the age of 111 years, the last seventy of which he drank freely of rum and brandy.

According to Mr. Finlayson, between 1813 and 1830, 290,309 individuals died at the age of 80 and upwards, out of 3,938,496, buried in England and Wales—making 73 per 1000; whereas, according to the tables of mortality in Prussia, the number of deaths from 1820 to 1834, at the age of 81 and upwards, was 207,599,

out of 5,457,209,—making the ratio only 38·7 per 1000. (*American Almanac* for 1839.)*

But if we are to credit the census taken in 1830, the number of centenarians in a white population of 10,845,729 in the United States, was 531, or one for every 20,425, and larger than the ratio in England, or perhaps any other part of the world excepting Scotland. What is still more remarkable, the number of slaves who had arrived at the age of 100 and upwards, was 1379 in a population of 2,010,436, or in the ratio of one for every 1457. But as it is known that the ages of negro slaves are often uncertain, it is probable that in the present case they have been exaggerated, and must therefore be received with caution. This opinion is corroborated by the fact, that from 1830 to 1840, the increase of slaves in the United States was 476,777, or about 2·32 per cent. annually; whereas that of the white population was 3,343,489, (including a large proportion of emigrants from Europe,) or at the rate of about three per cent. annually. I have not before me the free black population of 1830; but it was 386,235 in 1840; and the number of centenarians among them in 1830, is represented as 741. (*American Almanac* for 1832–40.)

As for the rest, life is longer in both the Middle and Southern States, if we except Mississippi, Louisiana and Florida, than in New England and other States north of lat. 40°.†

* According to the Report of the Registrar-General in the year 1839, there were 20,818 deaths in England and Wales at the age of 80 and upwards, and 121 at the age of 100 and upwards.

† From January 1, 1846, to January 1, 1847, about 50 per cent.

Dr. Bisset Hawkins states, on the authority of Ulpianus, that from the time of Servius Hostilius to that of Justinian, embracing about one thousand years, the mean duration of life among the free citizens of Rome was thirty years, which corresponds exactly with the present state of Italy, Greece and European Turkey. Plutarch also states, in his treatise on the *Defect of Oracles*, that Heraclitus reckoned thirty years as the age of man's life. And Mr. Strong tells us, that in 1839, in all Greece, the mortality under ten years of age was fifty-one per cent., which is less than that of Boston in 1846–47, or of New York and Philadelphia in 1850–51. But there is reason to believe that among the ancients, life was longer in those countries than among the moderns, especially in Greece. For Democritus is said to have died at the age of 108, Hippocrates at 104, Xenophon of Colophonia at 102, Xenophilus at 106; while Solon, Thales, Pittacus, and other sages, lived to the age of 100 and upwards. We are also informed by Lord Bacon, that during the reign of Vespasian, in the year 76, when the ages of the Roman people were registered, it was found that in the country between the River Po and the base of the Apennines, there were one hundred and twenty-four individuals who had arrived at 100 years and upwards —fifty-seven of whom were 110; four who were 130; and three 140:—that in the hilly country around Placentia, there were six individuals aged 110; four who

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of all the deaths in Boston were those of children under five years of age, excluding the still-born, which amounted to 11·2 per cent of the whole.

were 120; one woman 132; and one man, Marcus Aponius, of Rimini, 150. (*Life and Death.*)

Bacon also enumerates several individuals who had arrived at the age of 100 and upwards in the City of Rome,—among whom were Orbilius, Metellus, Clodia, Terrentia, the wife of Cicero, Luceia and Galeria,—while Statilia lived to the age of 99, and Livia, the wife of Augustus, to 90. But, although the clergy of Europe, as a class, are long livers, Bacon says, that among two hundred and forty-one Popes of Rome before his time, only five had arrived at the age of 80.

It is therefore probable, that during the high and palmy days of that great city, when supplied with an abundance of pure water, public baths, (at about a farthing for the poor,) and admirable sewers for carrying off filth, it was more healthy than during the reign of the Popes. The marshy districts around were also drained by Julius Cæsar and his successor, Augustus, by which the country was rendered more salubrious than at present. Nor was imperial Rome polluted by the effluvia from grave-yards—like London and many other modern cities.

Thus we perceive, that after making all due allowance for the influence of civilization, industry and the arts on the mean duration of human life, it is greater in the temperate latitudes of Europe than in either the north or south. And M. Quetelet has shown that in all parts of Europe, it is considerably greater in the country than in cities or large towns, in which it varies from 22 to 40·8 years in the middle and higher latitudes; but from 18 to 36 years in the south of Europe,—and that in Belgium the proportion is 46·9

in the country, to 36·9 in the towns. (*Treatise on Man*, p. 28.)

The difference is still greater in England and Wales, where, according to the Second Report of the Registrar-General, the mean duration of life is fifty years in the country districts, and thirty-seven in the large towns. And the diseases chiefly incident to children are twice as fatal in towns as in the country, as shown by the following table, contained in the Third Report. Deaths in 1,000,000 children:—

	Country Districts.	Town Districts.
By Hydrocephalus	419	1071
Convulsions	942	2586
Pneumonia	995	2028

From scarlatina, measles, croup, smallpox and whooping-cough the difference was about the same, or in the average ratio of 1999 to 4014.

We also learn from the Third Report, that in England and Wales the number of deaths in 1839–40 was 350,101,—of which 141,747 occurred under the age of five years, or in the proportion of 404 per 1000. From which it follows, that if we estimate the whole population of Europe at 250,000,000,* and the average annual mortality of individuals at all ages as one to forty, the number of deaths must be 6,250,000; and 2,525,000 before arriving at the age of five years. This enormous waste of life is owing greatly to the exposure of tender infants to cold and vicissitudes of

* Of this number, 25,000,000 are paupers, or about 10 per cent. of the whole. In England and France it is 10 per cent.; in Belgium and Flanders 20 per cent.; and in Ireland 33 per cent. of the whole population.

temperature, at an age when the power of generating heat is so small, that they often become chilled even during summer, if not sufficiently covered, or if suffered to remain in their wet clothes.

As a proof of what has just been observed, M. Quetelet has shown, that the mortality of infants is from 20 to 30 per cent. greater during winter than summer in Belgium,—that the maximum takes place at the end of winter, and the minimum about the middle of summer; that during the first month after birth it is in the ratio of 100 in January to 52 in July, and diminishes on to the twelfth year, when the influence of season disappears until the age of 40; during which time the power of obtaining heat by respiration is at a maximum. But after this period, the mortality in winter augments until the age of 80, when the ratio in winter is 100 to 51 in summer; while at 90, the difference is as 100 to 39. (*Recherches sur la Pop. et la Mortalité de l'Homme*, &c.) We also learn from the Reports of the English Registrar-General, that among aged people, and all individuals of feeble constitution, the mortality is from 30 to 50 per cent. greater during winter than summer; that whenever the mean temperature in London falls below 50·5°, the mortality increases progressively; that cold destroys a certain number of persons rapidly, and produces in others maladies which prove fatal in a month or six weeks, —so that the effects of a low temperature go on accumulating, and continue to be felt for thirty or forty days after the extremes have passed away. (*Third Report*, p. 108; *Letter of Mr. Farr.*)

The truth is, that the healthy growth of all young animals is retarded by cold, which is the great enemy

of infants, old people, and all individuals whose power of obtaining caloric from the atmosphere by respiration is imperfect. There is reason to believe, that nearly all infants are born with a sound organization, and therefore might be reared to maturity, if always maintained at an agreeable temperature, supplied with suitable nourishment, pure air, and allowed plenty of moderate exercise. Owing to improvements in wealth, science, diet, clothing, habitations, &c. the mean duration of life has augmented from 20 to 30 per cent. in the middle latitudes of Europe, within the last one hundred years; and the mortality of infants has diminished nearly 40 per cent. in the same time; for it has been estimated by statisticians of high repute, that between the years 1730 and 1750, it was about 740 per 1000 under six years of age. There cannot, therefore, be a rational doubt, that the general diffusion of sound practical knowledge of the animal economy among the people, would augment the average duration of life at least 50 per cent.

According to the researches of Dr. G. Emerson, the ratio of women to men living in Philadelphia, from the age of forty-five years and upwards, is as 100 to 74, among the whites, and as 100 to 69, among the blacks,—owing doubtless, to the greater amount of exposure, intemperance, &c. of men. The mortality of males to that of females, in the whole of the United States, is in the ratio of 100 to 97. (*American Journal of the Med. Sci.* Nov. 1827.)

In regard to the mean duration of human life in the warm and tropical portions of Asia, Africa and America, our information is exceedingly imperfect. But from all the best accounts I have been able to collect

from books of travels, there is reason to believe, that in southern Asia, northern Africa and central Ame rica, it does not exceed thirty years. For the Hindoos, Arabs, Egyptians and southern Chinese, are said to be old at fifty, and rarely live beyond seventy years, if we except the Brahmans and the wealthier classes in general, who avoid the noxious influence of a burning sun, and resort to frequent ablutions with cold water—by which health is preserved, and life often protracted to eighty, or even to one hundred years in some cases, especially in the extra tropical portions of India, China and Africa. It is seldom, however, that man arrives at the age of one hundred, even in the north of China, where life is longer than in the southern provinces. For we are informed by Sir John Sinclair, that when in the year 1784, the Emperor Kien Long ordered all the centenarians in his dominions to be numbered, only four could be found. (*Code of Health*, vol. i. p. 89.) In the *Companion to a Chinese Calendar* for 1832, edited by J. Morrison, it is stated that from a census taken in 1813, the official returns amounted to 362,447,183 souls, which M. Gutslaff has adopted as the most probable amount of the real population of that empire. Yet in the year 1827, when a census was taken by the Emperor Kang He, it was found that there were only twenty-one individuals in the empire who had arrived at the age of 100 years and upwards; 10,000 who were 90; and less than half a million who had attained to the age of 70 and upwards. (*Sharon Turner's Sacred Hist. of the World*, vol. ii. pp. 402–406.) But if we take the population of the

United Kingdom of Great Britain at 26,000,000, and the number of individuals who have arrived at the age of 70 and upwards must be 3,640,000, about eight times as many as in the entire population of China.

In the temperate climate of south Africa, the mean duration of life among Europeans has been found nearly the same as in England; while it is said that the Caffres also frequently arrive at the age of one hundred and upwards. Such, however, is not the case with either natives or foreigners in climates of perpetual summer, if we except a few small islands, which are exempt from extremes of temperature, and the impure air arising from putrefaction, combustion and the respiration of animals. For example, life is longer in Bermuda, Barbadoes and some other small islands, than in the same latitudes of America; while in Madeira and St. Helena, the average is said to be from forty-eight and a half to fifty years. From the facts collected by M. Moreau de Jonnés, as presented in the following table, we may form a general, though imperfect notion, in regard to the influence of a tropical climate on the mean duration of life among natives and foreigners. (See *Quetelet on Man*, pp. 27, 45.)

Batavia, 1805	Natives	40	years.
" "	Chinese	29	"
" "	Slaves	13	"
" "	Europeans	11	"
Bombay, 1815	"	18·5*	"
" "	Mussulmans	17·5	"

* It is stated by R. D. Thomson, in a recent work on Digestion, that among the Mahometans and Moguls of Calcutta, the mean value of life is thirty-six years; among the English twenty-eight years; the Armenians twenty-five; the Hindoos sixteen; and the native Christians fourteen,—making an average of nearly twenty-four years.

Bombay,	1815	Parsees	24 years.
Havana,		"	33 "
Guadaloupe,	1811 to 1824	Whites	23·5 "
"	" "	Free Blacks	35 "
Martinique,	1815	Whites	24 "
"	"	Free Blacks	33 "
Granada,		Slaves	22 "
St. Lucia,		"	20 "
Mean of the whole			24·5 "

Nor would the general result be materially different, if the Europeans were omitted in the estimate. We also learn from the sixth edition of Dr. J. Johnson's work on the *Diseases of Tropical Climates*, that the average annual mortality of the British troops in Bengal varied from 76·40 to 90·69 per 1000, from 1790 till the year 1810. According to the reports of Major Tulloch, it was 78·5 per 1000 among the white troops serving in the West Indies, from 1817 until 1836, or above five times greater than in the United Kingdom, where it was only 15·3 per 1000, and nearly the same in British America; whereas on the western coast of Africa, it varied from 483 to 668·5 per 1000. But he states, that among the black troops of Sierra Leone, including the slaves liberated by the English cruisers and settled there, it was only 30 per 1000, and about the same as the annual mortality of the whole slave population throughout the British West Indies. He adds, however, that the mean duration of life among the negroes of all ages does not exceed twenty-three years;* and that the annual number of births is not equal to the number of deaths.

* It is therefore not true, as maintained by Dr. Prichard and others, that the mean duration of life is about the same in all cli-

Such facts exhibit in a very striking manner the fatal influence of tropical climates on Europeans, compared with the negro race. But why is the mortality of the whites so much greater in central Africa than in the East and West Indies? And why so much greater in all hot countries than among the natives? The rationale of the latter fact has been already given, when treating of the manner in which the development of the chest, and the quantity of respiration are modified by external temperature, and will be further explained hereafter. The truth is, it is much easier to counteract the influence of external cold, by suitable clothing, habitations, artificial combustion and a liberal supply of animal or oily food, than it is to avoid the debilitating tendency of a burning climate, and the noxious exhalations which it inevitably engenders, wherever there is vegetable and animal matter in a state of decay.

The greater mortality of tropical Africa than of the West Indies, must also be sought in the vast difference between their climates. For although the mean annual temperature is nearly the same, it rises 20° higher during the heat of the day in central Africa, while it often descends to 60° at night, and sometimes to 50°, or even to 42° in the morning before sunrise,—making a diurnal range of from 50° to 70°; whereas in the West India islands it is only from 10° to 20°. Be-

mates. Solomon tells us, that fourscore was an extreme age in Judea. But we have seen that in Europe and the United States it is frequently twenty, and sometimes fifty or sixty years longer. And Dr. Smith, who resided some time in Peru, informs us, that at Lima, the mean duration of life does not exceed twenty years.

sides, owing to the vast bodies of alluvial lands, which are converted into swamps or morasses, by periodical inundations of the rivers in tropical Africa, a much larger amount of malaria is generated, than in islands of moderate size and a milder temperature.

Corresponding with this state of things, we learn from the travels of Adanson, Mungo Park, Winterbottom, Denham, Clapperton and others, that the negroes on the Senegal, Gambia and Niger, like those of Fezzan, Soudan and other portions of central Africa, are generally a feeble, indolent and phlegmatic race, who seldom live beyond sixty years,—who are gray, wrinkled and decrepid with age at forty-five; while in health, strength, beauty and intelligence, they are greatly inferior to the natives of the elevated plains of ancient Ethiopia and Abyssinia, or those of north and south Africa. But when removed to the milder climate of St. Domingo, and other West India islands, it is said by Collins and others, that in two or three generations, they improve greatly in all the endowments of body and mind. As a proof of this, some of the black creoles of Hayti have been distinguished for courage, ability, information and patriotism. We have also seen, that in the temperate climate of the United States, the increase of the negro population is nearly the same as that of the whites, notwithstanding the number of emigrants added annually to the latter.

It is therefore not true, as supposed by Dr. Prichard, that negroes are under the same disability to thrive and multiply in cold or temperate climates, as Europeans within the tropics. Nor is it true, as maintained by Dr. Caldwell, that "the negro is most healthy, long

lived, and attains the highest perfection of his nature in his native country." On the contrary, there is but little reason to hope from the history of the past, that he will ever rise much above the state of barbarism, in the tropical portions of his native country. Why then should men calling themselves philanthropists, be so anxious to remove the black population of the United States (where they multiply faster and live longer than almost any other people in the world) to the western coast of Africa, where the mean duration of life is not much above twenty years, as among the colonized blacks of Sierra Leone and Liberia? It is a reckless expenditure of money and life.

It is stated by Collins, in his work on the treatment of slaves, that the creole women of the West Indies are more fruitful than the natives of Africa, among whom abortions are frequent. It is therefore not surprising, that the population of tropical Africa has always been sparse. The women are also unfruitful in the north of Asia, Europe and America, where seldom more than three births are produced from one marriage; and where the mean duration of life is short. For example, it has been computed that in Iceland, (the climate of which is moderate compared with that of Asia or America in the same latitudes,) the annual mortality was one in thirty, from 1825 to 1831. (*Bibliothèque Universelle,* Oct. 1833, p. 177.) The prevalent diseases are said to be phthisis, pleurisy, jaundice, erysipelas, leprosy, elephantiasis and lowness of spirits.

That moderately warm climates are more favourable to fecundity than such as are cold, has been es-

tablished by the researches of Quetelet, who has shown that from the fortieth to the fiftieth degree of latitude in Europe, 100 marriages give 475 births; while from lat. 50° to 67°, the number is 430; and that in Portugal, it is 510, but only 362 in Sweden, —and greater in the south than in the north of France, in the ratio of 503 to 464. Perhaps there is no part of the world where the population increases so rapidly as in Ireland,*—especially when we consider the multitudes that emigrate annually to other countries; for, according to Professor Rau, it doubles every 28·6 years; in England, every 42·3 years; in Spain, every 41·9 years; in Prussia on the Rhine, every 52·33 years; in Austria, every 53·6 years; in France, every 110·3 years; in Sweden, every 118; and, according to M. Ch. Dupin, every 66 years in Russia. (QUETELET, *op. cit.* p. 51.)

It may be received as a fundamental axiom, that whatever is most delightful to the unperverted instincts of mankind, is most favourable to health, beauty, longevity, the development of all the higher faculties, and the perfection of human nature,—such for example, as a medium temperature, pure air and

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* Such is the delightful uniformity of temperature in the Green Isle, that at Cork, the mean of winter is about 43°, and that of summer 61°. When this beautiful country shall have thrown off the shackles of superstition, and obtained its political rights, it will advance in literature, science and the arts, with a rapidity proportioned to the physical superiority of its inhabitants. From all the foregoing facts and observations, it is evident that the climate of Europe is superior to that of all the other quarters of the globe, and that of the United States next,—if we except New Zealand and a few other small islands.

water, simple but nourishing food, moderate exercise of the physical, intellectual and moral faculties, especially of the domestic and social affections, and tranquillity of mind, which is the fruit of a well-spent life.* Nor is it less certain, that whatever excites painful or disagreeable sensations, is detrimental to sound health and long life, whether it be excessive heat or cold, too much or too little nourishment, excessive study, immoderate indulgence of the passions, impure air, the depressing emotions, nauseous drugs or intemperance in the use of spirituous liquors.

From the researches of Dr. Madden, contained in his work entitled *Infirmities of Genius*, it would appear, that, notwithstanding excessive intellectual exertion is a frequent cause of ill health and premature death, the mean duration of life among the learned and liberal professions is about forty-six years, if we deduct 30 per cent. for the mortality of infancy. For he found that by taking twenty individuals belonging to each of the professions devoted to science, literature and the arts, in different parts of Europe, the average was as follows:—

Writers on Natural Philosophy	74·7	years.
Moral Philosophy	70·8	"
Law and Jurisprudence	69·7	"
Medicine	68·4	"
Revealed Religion	67·7	"
Philology	66·1	"
Natural Theology	62·7	"

* It is stated by Sir John Sinclair, in his *Code of Health*, that after many years of research, he had not been able to find one case of an habitually wicked man who had arrived at a great age. The truth is, that the natural tendency to crime is in itself a fatal disease, and should be treated as such.

Artists	70·6 years.
Musical Composers	64·4 "
Novelists	62·8 "
Dramatists	62·4 "
Poets	57·2 "
Average	66·5 "

Dr. Charles Caldwell also informs us, that out of the fifty-six Americans who signed the Declaration of Independence, fifty-four lived to the age of 66 years and nine months. (*Physical Education.*)

But according to the researches of Caspar, as given by Quetelet, theologians live longer in Prussia than any other class; agriculturists next; and physicians the shortest period of all. More extended observations are required to furnish data for a sure induction.

According to the reports of Tulloch, life is longer among officers of the British army in the West Indies, than among privates, in the ratio of 7·8 per cent. to 4·2; while the mortality increases from the age of eighteen to forty and upwards. And we learn from the late report of Mr. Chadwick, on the sanitary condition of the labouring population in England and Wales, that the average value of life among the nobility and gentry is from 30 to 50 per cent. greater than among the tradespeople and mechanics; and that above 50 per cent. of all the children belonging to the labouring classes die under five years of age; whereas the ratio is only 25 per cent. among the gentry.* The

* According to the calculations of Dr. Grey, founded on the mortuary registration of 1839, the average age of all who die above 15 years of age, among the class of gentry and professional men

fatal influence of destitution would appear from the fact, that out of 12,313 individuals of all ages, in the English workhouses, 2552 deaths occurred in 1838, or about 20 per cent. of the whole. (*Lancet*, May 1, 1841.) Even in the hospitals and infirmaries of England, the mean annual mortality varies from 4 to 11 per cent. according to *Porter's Progress of the Nation*.

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is 59 years; while among tradesmen and the labouring class it was 49 and 48 years; the liability to consumption among the latter being about twice as great as among the former. Both in Paris and London the mortality among the working classes is nearly double what occurs among the more wealthy.

CHAPTER III.

INFLUENCE OF CLIMATE AND SEASON IN MODIFYING THE DISEASES OF MANKIND.

"The time may come when, guided by yet undiscovered knowledge, new and more direct principles, the tendency to tubercular and other morbid formations, may be surely checked, chronic inflammations cured, and fever suspended in its first movements."—CONOLLY.

A COMPLETE history of the mode in which the diseases and mortality of the human race are modified by external temperature, regimen, clothing, habitations, employments, and the various modes of living, would afford more practical information in regard to the causes, prevention and right method of treatment than all the systems that have been invented within the last two thousand years; for it would enable us to reduce the heterogeneous and chaotic mass of facts that constitute the sum of medical literature, to the certainty of an exact science. And that such an important undertaking might be, to a great extent, accomplished in a short time, by the combined exertions of a few enlightened individuals, is manifest from what

has been recently done in Great Britain by the Reports of Major Tulloch and those of the Registrar-General, aided by the judicious researches of Mr. Farr and other statisticians.

The diseases of man are no less modified by climate and season, than the various mechanical, chemical and physiological operations of our planet—being as different in the tropical portions of Africa, India, South America and the West Indies from what they are in the temperate and higher latitudes, as are the botanical and zoological characters of those regions.

The following tables, constructed from the Reports of Tulloch, laid before both Houses of Parliament, exhibit the average annual ratio of mortality per 1000 mean strength of the British troops serving in different parts of the world, from 1817 to 1836, omitting epidemic cholera:—

TABLE I.

	United Kingdom.	The Canadas.	Nova Scotia and N. Brunswick.	Mediterranean Command.	West Indies.	Jamaica alone.	Sierra Leone.	Cape Coast Command.
Fevers	1·4	2·4	1·6	13·0	36·9	101·9	410·2	382·6
Eruptive Fevers	0·1	0·2	...	...	...	...	...	...
Diseases of the Stomach and Bowels	0·8	1·3	1·5	3·5	20·7	5·1	41·3	220·6
Diseases of the Liver	0·4	0·2	0·2	0·8	1·8	1·0	6·0	14·3
Respiratory Organs	7·7	6·7	7·1	4·8	10·4	7·5	4·9	1·6
Diseases of the Brain	0·7	1·2	1·3	1·0	3·7	2·6	4·3	1·6
Dropsies	0·3	0·4	0·5	0·6	2·1	1·2	4·3	3·2
All other diseases	2·7	1·6	1·1	1·5	2·9	2·0	12·0	44·4
Total	14·1	14·0	13·3	25·2	78·5	121·3	483·0	668·3

TABLE II.

Exhibiting the average annual ratio of Mortality per 1000 *of Black Troops serving in the West Indies, Sierra Leone and the Southeast Coast of Africa.*

	West Indies.	Sierra Leone.	Cape of Good Hope.
From Fevers	4·6	2·4	0·7
Eruptive Fevers	2·5	6.9	...
Diseases of the Stomach and Bowels	7·4	5·3	4 8
Diseases of the Brain	0·9	1·1	0·5
Respiratory Organs	16·5	6·3	3·9
Dropsies	2·1	0·3	...
All other diseases	3·8	6·2	1·0
Total	40·0	30·1	10·9

Thus we perceive, that in Great Britain, the Canadas, Nova Scotia and New Brunswick, about one-half of the mortality is from diseases of the respiratory organs; whereas in the warm climate of the Mediterranean they form about one-fifth of the whole; in the West Indies nearly one-seventh; and not one one-hundredth part among the white troops in tropical Africa. We are also informed by Tulloch, that in the East Indies, where the mean annual mortality varies from seventy to ninety per 1000, nearly the whole was from fever, dysentery, cholera, diarrhœa and disease of the liver; that among 74,850 native troops serving in Madras, the mean annual ratio was only one per 1000 from all diseases of the lungs; and but 2·4 in the Mauritius and at St. Helena. We further learn from the last edition of Dr. James Johnson's work on the *Diseases of Tropical Climates*, that from 1827 to 1836 the proportion of deaths from diseases of the respiratory organs was one-eleventh of the whole at Calcutta; at Chinsurah one-sixteenth; and at Berhampore one-twentieth. In north Africa, the mortality from phthisis is

still less, according to M. Guyon, a medical officer of the French army, who states that from 1838 to 1841 it was only one-fortieth of the whole among the Moors at Algiers; among the Jews, one-thirty-seventh; and about one-twentieth among Europeans. It is also well known, that diseases of the lungs are comparatively rare among the nations of Egypt, as in South America, and almost unknown in the Sandwich Islands. The physicians of ancient Rome were in the habit of sending their consumptive patients to the valley of the Nile.

But why is it, that the mortality from diseases of the lungs is so much greater among negroes of the West Indies than among Europeans? And why are the latter so much more liable to fevers, when removed to tropical climates, than the natives? The solution of these queries must be sought in the radical difference of organization of men and other animals in cold or temperate and in hot climates. For example, we have seen that, owing to the high temperature of tropical Africa, for the greater part of the year, during the heat of the day, respiration is proportionally diminished, and the lungs exercised less, than in colder climates, by which the size of the thorax is accommodated to the wants of the system; so that when removed to the West Indies, where the maximum temperature is from 10° to 20° lower, the natives of Africa are unable to obtain caloric from the atmosphere by respiration, as fast as it is abstracted by the surrounding media, especially in the high lands, or during the prevalence of northerly winds, and early in the morning when the air is damp.

The consequence is, that under such circumstances, they are often found shivering with cold, but never complain of the most intense heat of the sun, which is no less delightful to their feelings than conducive to their health; that during winter, when northerly winds prevail, and the air is much cooler than at any other season, they are extremely liable to catarrh, influenza, pneumonia, pleurisy, and other diseases of the lungs, including rheumatism, eruptive fevers, dysentery, diarrhœa, colic and tetanus—all of which are brought on by exposure to cold, damp air, a shower of rain, and often by sleeping in damp clothes, by which the circulation through the lungs and general system is greatly diminished and perspiration checked, followed by congestion of the stomach and bowels, or of the pulmonary organs. Nor is it until several generations after his removal to a colder climate, that the thorax of the African is developed to the same extent as that of the European; so that, like the monkey, the lion, tiger and leopard, he is proportionally subject to diseases of the lungs. On the other hand, as the lungs are more exercised in temperate and cold climates, the thorax is more highly developed among the whites, who therefore obtain a larger amount of caloric by respiration, *cæteris paribus*, by which they are enabled better to resist the influence of a low temperature. But for this very reason, when removed to the burning climate of tropical Africa, India and America, they receive caloric from the atmosphere by respiration faster than it is carried off, causing the temperature of the body to rise above the natural standard, and predisposing it to attacks of malignant fever.

According to an estimate of Mr. Farr, published in

the Second Report of the Registrar-General, the mortality of England and Wales in 1838 was 342,559 in a population of 15,441,735, or in the ratio of 22·11 per thousand of all ages, and from all diseases—which is 7·8 per cent. higher than among the British troops in the United Kingdom from 1817 to 1836. The reason of this difference is, that the army is composed of men chiefly in the prime of life; whereas in the civil population of England and Wales, 130,695 of the deaths were of children under five years of age, or in the ratio of above 40 per cent. of the whole mortality. And we have already seen that, throughout the temperate and colder latitudes of Europe, a large proportion of the deaths among children are owing to the influence of cold, at a period when the power of maintaining the temperature at the natural standard is limited, and the whole organization extremely delicate.

In England and Wales, the mortality from all the diseases registered in 1838 was as follows, according to the classification of Mr. Farr. (See *Second Report of the Registrar-General*, p. 100.)

DISEASES OF THE RESPIRATORY ORGANS.

Consumption	59,025	Influenza*	806
Pneumonia	17,999	Pleurisy	582
Asthma	5,745	Tonsillitis	432
Whooping-cough	9,107	Laryngitis	99
Croup	4,463	Doubtful	2,568
Hydrothorax	2,306		
Bronchitis	2,067	Total	105,199

* In the tables of Mr. Farr, influenza, croup and whooping-cough are classed as epidemics. But they also belong to the respiratory organs, as much as catarrh or pneumonia, and ought to be classified as such. And as inflammation is common to almost every class of diseases, their division into inflammatory and non-inflammatory is often fallacious.

DISEASES OF THE NERVOUS SYSTEM.

Convulsions	26,047	Insanity	367
Hydrocephalus	7,672	Tetanus	129
Apoplexy	5,630	Delirium Tremens	182
Paralysis	4,975	Chorea	24
Cephalitis	2,178	Doubtful	1,407
Epilepsy	1,093		
		Total	49,704

FEVERS, EPIDEMIC AND CONTAGIOUS DISEASES.

Typhus	18,775	Erysipelas	1,203
Remittent Fever	182	Syphilis	159
Ague	44	Hydrophobia	24
Smallpox	16,268	Thrush	1,090
Measles	6,514		
Scarlatina	5,802	Total	50,061

DISEASES OF THE DIGESTIVE ORGANS.

Gastritis and Enteritis	6,061	Tabes Mesenterica	724
Diarrhœa	2,482	Peritonitis	168
Dysentery	627	Ascites	63
Cholera	331	Intussusception	233
Hepatitis	449	Stricture	111
Jaundice	841	Hæmatemesis	111
Hernia	507	Teething	4,404
Colic	619	Doubtful	3,978
Worms	749		
		Total	22,463

DISEASES OF UNCERTAIN SEAT.

Dropsy	12,342	Debility	12,634
Inflammation	5,816	Atrophy	2,018
Abscess	1,478	Gout	207
Mortification	1,343	Malformations	166
Hæmorrhage	1,218	Sudden deaths	3,012
Carcinoma	2,448	Scrofula	1,119
Tumors	373		
		Total	44,232

From diseases of the skin, urinary, sexual and locomotive organs, the number of deaths was	7,436
Old age	35,564
Violent deaths	11,727
Intemperance	161
Starvation and want	167
Total	55,055

From the foregoing tables we perceive, that in England and Wales, a much larger number of individuals die from diseases of the respiratory organs than from any other class of maladies. And Mr. Farr has shown that in the metropolis, from January, 1838, to June, 1841, or three years and a half, the number was much greater during winter than any other season, as represented in the next table:—

	Winter.	Spring.	Summer.	Autumn.
Consumption	5,600	5,778	5,501	5,148
Pneumonia	3,326	2,454	1,827	3,600
Asthma	1,733	642	344	1,080
Whooping-cough	1,674	1,208	644	787
Bronchitis	495	307	191	347
Hydrothorax	272	183	136	206
Pleurisy	70	62	39	51
Influenza	67	48	24	46

The greatest number died from consumption in spring, owing to the result of the previous winter's cold, as suggested by Mr. Farr. But this is not the only class of diseases that prove more extensively fatal during winter than any of the other seasons, as will be seen in the following table, the upper line of which represents the mortality of London from all diseases in 1838.*

* Mr. Farr says, that the ratio of mortality in the different seasons has been about the same in England for the last one hundred and forty years, and is doubtless nearly so in all climates, in which the heat of summer is not sufficient to generate malignant epidemic fevers. And it is stated by Dr. Heberden, that from 1795 to 1799, the mortality of London was 13,406 in winter, 12,904 in spring, 9678 in summer, and 10,226 in autumn. He also states, that during five weeks, from the 31st of December, 1794, to the 3d of February, 1795, the mean temperature in the morning was 23°, and the whole number of burials 2823; whereas, in an equal period, between the 30th of December, 1795, and the 2d of February, 1796, the temperature was 43·5° in the morning, and the mortality only 1471, making a difference of

	Winter.	Spring.	Summer.	Autumn.
	15,611	13,109	11,937	12,581
Apoplexy	299	241	201	246
Paralysis	234	181	135	187
Dropsy	501	427	375	465
Typhus	1,285	1,175	829	788
Old age	1,383	969	778	981
Sudden death	216	165	105	146
1838 to 1841.				
Diseases of child-bed	310	261	217	309
Diseases of the heart	739	556	571	698
Mortification	217	177	153	171
Ulcers	23	16	9	13
Phlegmons	9	2	3	1
Rheumatism	124	113	99	117
Insanity	73	45	35	42

(*Second Report of the Registrar-General*, pp. 88, 90, 98; *and Third Report*, p. 105.)

From the 1st of January, 1838, till the 1st of June, 1841, the mortality of the metropolis from diseases of the digestive organs was, during winter, 1982; in spring, 2139; in summer, 2978; and in autumn, 2263.

The facts contained in the foregoing tables, especially the two last, are exceedingly instructive in a theoretical and practical point of view, as showing the influence of external temperature in modifying the general character of diseases, together with the true method of treating, or rather of preventing them. Should pathologists still assert, as they have long done, that phthisis depends on a *hereditary predisposition to the formation of tubercles*, I answer, that the hereditary predisposition is engendered chiefly by cold, because rare in hot climates. And if less prevalent in

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nearly 100 per cent. According to Dr. Emerson, the mortality of adults is nearly the same at Philadelphia, in all seasons of the year; while that of infants is from 30 to 40 per cent. greater during summer than autumn, winter and spring.

Russia than in Great Britain, France or Germany, it is because more attention is paid to clothing and the warming of houses in Russia, where the temperature is kept at about 70° within doors throughout the winter. Besides, in the north of Europe, the atmosphere is generally clear and dry. In the United States north of 40°, where the mean temperature of winter is from 25° to 34°, the mortality from diseases of the lungs has been estimated at from 25 to 30 per cent. But in the middle latitudes of Europe it is about 20 per cent.; and varies from 12 to 15 per cent. in Italy, Spain, Portugal, Greece, the Ionian Islands and the southern States of North America; while within the tropical portions of Asia, Africa and other parts of the world, it forms a very small proportion of the whole, as we have already seen.

Should it be urged, that a large proportion of the deaths in the West Indies are from phthisis, this apparent exception to the general law, is partly explained by Sir James Clark, in his late valuable *Treatise on Climate.* For he states that it was formerly the custom to draught seamen, labouring under chronic diseases of the lungs, into ships going to the West Indies. He further informs us, on the authority of Ferguson, Musgrave, M'Arthur, Melville, Arnold and other respectable medical writers, who had long resided there, that the climate is highly favourable to individuals *predisposed* to the tuberculous diathesis; but that, like all other hot countries, it hastens death in advanced stages of the disease. That it is generally brought on by exposure to the cool night air, intemperance and improper diet, would appear from the fact, that the

mortality from phthisis is four times greater among privates than officers. Whatever impairs the process of sanguification, causes the blood to deposit imperfectly organized albumen, and this tends to produce tubercles. Sir James adds, that in the case of Dr. Heinekin, who remained several years in the mild climate of Madeira, (the mean annual temperature of which is 68·6°,) after extensive ulceration of the lungs, and nearly the total loss of one lobe, his health always improved during summer, and declined in winter.*

I have also frequently observed, that persons of small chest and delicate constitution are afflicted with cold extremities and general chilliness, even during summer, while labouring under asthma or incipient phthisis; and that in some cases, the chemical function of the lungs was so far diminished, that it was difficult to maintain the temperature of the body at the normal standard, even before a fire that was oppressive to persons in good health. There cannot therefore be a doubt, that the temperature most favourable to individuals of weak lungs is one from 70° to 75°, according to the more or less advanced stage of the disease; and that breathing an atmosphere below 65° inevitably tends to aggravate all the

* The late autopsical researches of Roget and Boudet in Paris, and of J. H. Burnet in Edinburgh, have shown from indiscriminate examination in large hospitals, that puckerings, cicatrices, cretaceous concretions and other evidences of tubercle in the lungs, occur in at least one-third of all the individuals who die after the age of forty, in Great Britain and France. The curability of phthisis is therefore an undeniable fact, even when large ulcers have been formed.

symptoms. The right plan is to maintain a temperature sufficiently high to prevent the circulation from becoming depressed. At the same time, we must admit with Sir James Clark, that many individuals are predisposed to this fatal malady by impure air, an impoverished diet, a sedentary life, the depressing emotions, excessive medication, (especially the use of mercury,) chronic disease from any cause, or whatever diminishes the natural vigour of the constitution. (*Op. cit.* pp. 47–306, third edition.)

Yet it is evident from all the foregoing facts and observations, that the tuberculous diathesis, as well as all inflammatory affections of the lungs, are generated chiefly by the depressing influence of external cold, and might be prevented in nine cases out of ten, by keeping the system at the natural standard, and maintaining a free circulation through the lungs, skin and extremities. Nor would it be very difficult for intelligent individuals in good circumstances, to regulate the temperature of their own private residences during the colder months, so as to obtain all the advantages of an artificial warm climate, if we except exercise in the open air. But as the same advantages might be secured in a far more effectual and economical manner, by the establishment of a large Sanatorium for the reception of patients labouring under chronic affections of the lungs, it is greatly to be desired that such an institution should be founded in some healthy place near every large city, with intelligent superintendents to regulate the temperature of the rooms, the diet, clothing, exercise, amusements, &c. of the inmates, who would in many respects be better off than in a foreign clime.

The manner in which diseases are produced by the influence of external cold, or by anything which reduces the temperature of the body below the natural standard, has never been satisfactorily explained. Nor is this very surprising when we reflect, that physiologists have never yet ascertained the specific office of animal heat in circulation, sanguification, secretion, nutrition, sensation and muscular motion. For if our pathology and methods of treatment are still imperfect, it is because the fundamental problems of physiology remain unresolved. Why then is it that catarrh, influenza, croup, whooping-cough, pneumonia, bronchitis, pleurisy and phthisis, are so much more prevalent in the higher latitudes during winter than summer, and at all seasons than in tropical and warm climates?

I answer, because the pulmonary air-cells and Schneiderian membrane of an adult man present to the atmosphere an area of about 16,800 square inches, which is above seven times greater than the whole cutaneous surface of the body; and that in cold climates, they are exposed to the paralyzing influence of a low temperature, more constantly than any other part of the system. The consequence is, that as animal heat is the immediate cause of all vital action, the chemical function of the lungs, sanguification and circulation, are diminished, constituting the first link in the chain of the morbid phenomena, which are essentially the same in all cases, modified, however, by the condition of the system, the nature of the part more immediately affected, and the greater or less intensity of the exciting cause.

If the exposure be slight or of short duration, and the lungs are sound, the result is what we denominate a common cold, which presents in a mitigated form all the essential conditions of fever. It is generally brought on by sitting in a cold room, exposure to damp or cold night air, a shower of rain, getting the feet wet and often by sitting in a current of air when fatigued by exercise. The first effect of which is, that the capillary vessels of the lungs and Schneiderian membrane are weakened, the circulation through them diminished and respiration of course impeded, attended with a sensation of chilliness,* which is increased by the slightest current of air. In this enfeebled condition of the capillaries, the lungs and lining membrane

* Dr. Edwards relates the case of a vigorous young man, who fell into the River Seine when it was full of floating ice, and with difficulty escaped by swimming; after which he continued chilly for three days, even before a warm fire. In this case, the circulation through the lungs was so far paralyzed by the immersion, that respiration was diminished. A similar case was related to me of a mechanic, who, after fatiguing himself by over-exertion, imprudently bathed in the River Wye, in the month of April, until he became chilled, which produced torpor and congestion of the lungs, that ended in what is called hepatization of their substance. And so far were the air-cells thus obstructed, that he suffered a sensation of coldness throughout the following May and June, when he was removed in a state of extreme debility to St. Bartholomew's Hospital, where he soon afterwards expired. Now can any rational individual doubt, that an early application of the warm bath would have aroused the torpid circulation, restored the natural function of the lungs, and thus have prevented all the fatal symptoms that followed? Would not this delightful remedy be equally efficacious in the early stage of all diseases that are ushered in with chilliness? And if so, is it not the duty of every family to have a warm bath in the house?

of the throat and nostrils become congested with blood, when effusion of serum takes place, attended with coughing, sneezing and a thickening of the membranes, by which the bronchi, trachea and nostrils are more or less obstructed, the free inspiration of vital air impeded, the arterialization of the blood and its circulation throughout the body diminished, and all the secretions deranged.

Owing to the stoppage of perspiration, the skin is dry, tender to the touch and no longer carries off two or three pounds of water per day, as in health. The consequence is, that it is retained in the blood, (unless carried off by the vicarious action of the kidneys,) by which its power of uniting with the solids and maintaining the secretions is diminished; so that a portion of the caloric which is usually employed in these vital operations, and then carried off with the various excretions, is retained in the blood, causing a slight increase of temperature, termed catarrhal fever. But as the healthy activity of all the organs depends on the continual transfer of caloric, in combination with arterial blood to the solids, by which their composition and power are continually renewed, it is evident that whenever secretion and nutrition are diminished, there must be a corresponding reduction of sensorial and muscular power. Hence it is, that the acuteness of the senses and intellectual faculties is more or less impaired, while there is a general feeling of languor, stiffness and aching or soreness of the limbs, if not of the whole body, attended with a furred tongue, impaired appetite, and a feeling of drowsiness.

Such is the brief, but true history and theory of the

most common disease that afflicts the human race and all the higher animals; for it is the *roup* in poultry, the *distemper* among dogs, horses and other mammalia; nearly all the complaints of which are brought on by the immediate influence of external cold. If, owing to a change of wind, the temperature is suddenly reduced 20° or 30°, over a large extent of country, the disease becomes more violent and assumes the character of a wide-spreading epidemic, termed influenza, which prevails occasionally at all seasons, but is generally much milder and of shorter duration in summer; because at that season, the reduced temperature that brings it on, is soon followed by warm weather.* For the same reason, it seldom occurs in

* It has been often asserted by medical authors, that epidemic influenza is not brought on by cold, nor vicissitudes of temperature, because it sometimes appears during summer. But in temperate climates, the transitions from heat to cold are often greater and more sudden during summer than winter. Nor is it surprising that the disease should exist in the tropical portions of India and Africa sometimes, though rarely, when we reflect that the diurnal temperature of those regions varies from 30° to 50°. Dr. Dieffenbach maintains, that epidemic influenza is generated in the middle latitudes of the northern hemisphere, by a *peculiar miasma*, originating in the northern portions of Europe, Asia and America. He also states, that in Europe, it spreads from the northeast to the southwest, with the speed of the prevalent wind, and diminishes in violence with the distance from its origin. However this may be, it may be asserted with confidence, that in no climate nor season, is the imaginary *miasma* competent to produce the epidemic, without a reduction of temperature; and it is well known to be most prevalent when the fluctuations of temperature are greatest and most frequent. Dr. Forry has shown, that the ratio of catarrhal diseases among the soldiers of the United States, is more than twice

tropical climates, where it soon passes away, and manifests but slight severity. When it comes on with a cold northerly or easterly wind, after the powers of life have been diminished by a hot summer, and the prevalence of a malarious atmosphere, it assumes the type of a more malignant fever, ushered in by spasmodic shuddering, pains in the head, back and limbs, loss of appetite, hot and dry skin, constipation, red urine, derangement of all the secretions and a general prostration of strength.*

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as great in winter as in summer, and nearly four times greater in the northern States, than in the Peninsula of East Florida, (lat. 24° 33′,) where the mean difference between the temperature of winter and summer is only 11·34° F. (*Climate of the United States*, p. 263.) In 1708, Lancisi observed that those who were exposed to the inclemency of the season were attacked with influenza, while those who kept themselves from cold escaped. (*Brit. and For. Medico-Chir. Rev.* for July, 1849, p. 93.) In fact, without a loss or deficient supply of vital caloric, the influenzal *miasma*, like some others, would be harmless.

* According to the Registrar-General, the average mortality of London during the last week in November, is 1045. But during the prevalence of influenza it rose to 1677 in the last week of November, 1847; in the first week of December, 2454 deaths were registered, and in the second week, 2416. The excess of mortality during nine weeks was 6066 over the average; only 1157 of which were referred directly to influenza; the remainder being attributed to an increase of asthma, bronchitis and pneumonia. The mortality of childhood was augmented 83 per cent., of manhood 104 per cent. and of old age 247 per cent. The Registrar-General calculates that about 500,000, or one-fourth the inhabitants of the metropolis were attacked; making the mean ratio of deaths throughout the epidemic, one out of 82·44. It began on the 16th of November, on which day the wind changed from southwest to northwest, and the temperature of the air suddenly fell from 11° above to 10°

If from any local cause, the membrane lining the treachea or larynx is weaker than any other part of the respiratory apparatus, the same kind of exposure that induces catarrh in ordinary cases, brings on inflammation of the parts, with an effusion of lymph, by which the free admission of air into the lungs is obstructed and suffocation produced, as in croup and laryngitis,—unless the debility and congestion of the capillaries be speedily removed by local depletion, fomentations to the throat, the frequent use of hot gargles, warm drinks, the inhalation of steam and whatever tends to equalize the circulation, restore the action of the lungs and bring on perspiration.

If from any cause, the capillaries of the lungs, bronchi or pleura, are in a weak state, the same exposure induces congestion and inflammation, followed by the effusion of serum, lymph and sometimes red blood, by which respiration is impeded and sanguification greatly diminished, as in pneumonia, bronchitis and pleurisy.* If at an early stage of their progress,

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below the average. (*Report of Registrar-General.*) At St. Petersburg, in 1782, 40,000 persons were attacked in one day, immediately after an extraordinary fall of the thermometer. This epidemic was called La Russe throughout Europe. (*Brit. and For. Med.-Chirurg. Rev.* July, 1849, p. 110.) And it was observed during the fatal influenza of 1848, in England, that the places where the inhabitants suffered least, were characterized by *dryness, warmth and shelter from a humid atmosphere.* It is therefore manifestly under the control of science and care.

* We have seen that asthma is five times more fatal in England and Wales during winter than summer. In a very large majority of cases, respiration is so far diminished, owing to an obstructed state of the lungs, that the temperature of the body is generally

the circulation through the lungs and general system can be restored by the inhalation of steam, the use of hot drinks, the application of dry heat to the chest and other parts of the body, all immediate danger is removed and the disease rendered mild or of short duration. But if the congested state of the capillaries be suffered to remain for some time, the nutritive properties of the blood and its coagulating power are so far impaired, that the local symptoms are followed by general fever, loss of appetite, pain in the head, back and limbs, prostration of strength, delirium, coma and subsultus tendinum, as in typhoid pneumonia, and what has been called *bilious* pleurisy.

If the chest be small, the lungs imperfect and the general powers of the constitution enfeebled by impure air or impoverished diet, want of exercise and the depressing emotions, exposure to a cold atmosphere, a shower of rain or to damp night air, with thin clothing, after the body has been fatigued with

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below the natural standard, and sometimes, from 10° to 20°, according to the observations of Dr. Bree, attended with a spasmodic condition of the respiratory muscles, fits of partial suffocation, a deranged condition of the blood, and of all the secretions, followed by thirst, high-coloured urine, and other symptoms of fever, when the chemical function of the lungs is not too far diminished to prevent reaction. But although exposure to cold is the common predisposing and exciting cause of the disease, it is, like phthisis, aggravated by the rarefied air of heated rooms and by hot sultry weather, which also diminish respiration and often produce syncope. We have also seen that whooping-cough is nearly three times more fatal during winter than summer,—which shows, that, like all diseases of the respiratory organs, it is brought on chiefly by the influence of external cold, and should be treated by regulating the temperature of the patient.

exertion, or weakened by sitting in a crowded assembly, the capillaries of the lungs are so far debilitated, that the free circulation of blood through them is greatly obstructed, respiration and sanguification are diminished, attended with cold extremities, derangement of all the secretions and general loss of strength, owing to the impoverished condition of the blood, which is no longer capable of duly nourishing the solids. In this state, the cohesion of the pulmonary capillaries is so far overcome, that an effusion takes place into the air-cells, of serum, albumen and lymph, which are gradually converted into tubercles,* that vary from the size of a pin's head to that of a pea, or even of a small walnut,—after which they dissolve into a semi-fluid pus, that is discharged from the lungs by coughing. And it is because the upper portion of the lungs is most exposed to the torpifying influence of cold air, that tubercles are generally first produced there. It is also because the lungs and pleura are more exposed to vicissitudes of temperature than the

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* It was supposed by Hippocrates, that all diseases of the throat and lungs were owing to the excess of *phlegm*, and that its effusion into the air-cells gave origin to the formation of tubercles, which on putrefying became pus. Within the last hundred years, it has been the fashion to regard tubercles as the cause of phthisis. But if it be true, that the tubercular diathesis is comparatively rare in tropical and warm climates, like all pulmonary diseases, they must be regarded as secondary effects arising from exposure to cold, which is also the cause of excess in the quantity of phlegm. According to Dr. Alison, above one-third of the deaths in Edinburgh under fifteen years of age, are from scrofulous diseases, which are well known to be still more prevalent in the north of Europe, and more so in all the higher latitudes during winter than summer.

abdominal viscera, that the latter are less liable to inflammation during cold weather than the thoracic organs.

Such are the leading symptoms of phthisis, which, in almost every case, may be traced to inflammation of the lungs and bronchi, or to the influence of repeated colds that have been neglected, and which, in nineteen cases out of twenty, might have been avoided. But if suffered to run on till ulceration of the lungs is fully established, all rational hopes of a permanent cure must be given up. The only successful method of treating this fatal malady is, to prevent its actual formation, by avoiding all the predisposing and exciting causes, or to arrest its progress at an early stage, by placing the patient in a genial atmosphere, and supplying whatever is calculated to restore the languid circulation of the lungs. For it will be proved hereafter, that all congestions, inflammations and effusions depend on debility in the capillaries of the part affected. And if there be anything in nature that deserves the name of *panacea* or *universal remedy*, it must be that agent or principle which maintains all the organs of the animal economy in a healthy state, renews the composition of lost parts, and that of the whole body, when wasted by illness, from whatever cause. This doctrine was in part recognized by Hippocrates, Erasistratus, Herodicus, Asclepiades, and other ancient physicians, who treated inflammation of the lungs, pleura, throat and other parts of the body by the inhalation of steam, by hot gargles, external fomentations, the warm bath and friction, the application of heated iron, or bags of hot sand, ointments, cataplasms, cere-cloth and wrapping the part with woollens.

Sir James Clark informs us, that in Paris, the mortality from consumption is greater among females than males, in the ratio of thirteen or fourteen to ten; and that in Berlin the difference is still greater between girls and boys. But at Hamburg, Geneva and New York there is a slight excess among males. According to the Report of the Registrar-General, the mortality was 31,090 throughout England and Wales in the year 1837–38, among females; and 27,935 among males. Mr. Farr rightly ascribes the difference partly to the sedentary life of females, and partly to compression of the chest by costume; both of which diminish respiration, and impair the vital properties of the blood, which deposits tuberculous matter with an unnatural facility. (*Second Report of the Registrar-General*, p. 73.) The evil is doubtless aggravated by exposure of the neck, shoulders and arms, the want of sufficiently warm clothing in winter, (especially of flannel drawers when the constitution is delicate,) thick stockings, boots and shoes.*

According to Lombard and Papavoine, above 25 per cent. of all who die in Paris, from birth to puberty, are affected with tuberculous disease, which is most pre-

* In his excellent work on *Pulmonary Consumption*, Dr. Morton justly observes, that a large proportion of the cases that occur between the ages of eighteen and thirty years might have been prevented by a proper attention to dress in childhood; that no infatuation is more preposterous than that which is familiarly called the *hardening* of children, by exposing them half-clothed to every vicissitude of temperature, and by subjecting them to injudicious cold bathing, which cannot be borne by delicate children, nor by any but those that are robust; and that even they are often destroyed by it.

valent during the third, fourth, fifth and sixth years, *but is extremely rare in the first year of infancy.* We are also informed by Sir James Clark, that in all the numerous examinations of Velpeau and Breschet, they found no tubercles in the fœtal state; and that M. Guizot discovered none while dissecting four hundred new-born infants; but that after the second year, they were found by M. Guersent to be extremely prevalent in the Hôpital des Enfans Malades, in Paris. (*Cyclop. of Pract. Medicine*, No. 22, pp. 307–8.) From which it would appear that, even when there is an hereditary predisposition to the disease, it is not discoverable till after birth, when it is developed by exposure to cold, and by the various causes that tend to produce tubercles at all periods of life; and which causes are equally essential to the original production of hereditary diseases.

It is frightful to contemplate the aggregate amount of disease, suffering and mortality that arise in temperate climates, from ignorance or inattention in regard to the danger of simple exposure to cold, currents of air and getting wet, especially when the body is fatigued by over-exertion; and the irreparable loss to the public of individuals in the prime of life, distinguished for ability and usefulness.* We have seen

* The last illness of General Washington was brought on by exposure to a sleety rain, while riding over his farm, (on the afternoon of the 13th of December, 1799,) from which he returned shivering with cold. A sore-throat and hoarseness came on during the night, and rapidly increased, until respiration became difficult, and very soon destroyed life by suffocation. That of General Harrison was also induced by exposure to a cold misty rain, during a long

that, from diseases of the nervous system, old age and sudden deaths, the mortality is nearly double in win-

walk before breakfast, in the month of March; soon after which he was attacked with a chill that lasted several hours, causing torpor, congestion and an apoplectic state of the thoracic and abdominal organs, followed by a low fever, that terminated fatally in a few days. The melancholy death of Robert Burns in the meridian of life, was caused by exposure to cold, damp night air, after a fit of intemperance; and by sea-bathing, recommended by his medical adviser, when reduced to a state of great debility. He returned home late at night, benumbed with cold, which brought on an attack of rheumatism. And it is stated in the *Lancet*, of Feb. 20, 1841, that the last illness of Sir Astley Cooper, who died of hydrothorax, was brought on by his neglecting to put on proper clothing during the previous October and November. The Duke of Kent, the father of Queen Victoria, lost his life, in the fifty-third year of his age, from inflammation of the lungs, brought on by a neglected cold, caused by a long walk in the environs of Sidmouth, and getting his "boots thoroughly soaked." Although urged by Captain Conroy to change his boots and stockings, this was not done till he dressed for dinner, when he became chilly and hoarse. The next day he was dangerously ill from inflammation of the lungs and general fever; for which he had one hundred and twenty ounces of blood taken from the arms and by cupping, without any relief; and he expired on Sunday forenoon, on the 23d of January, 1820, and the fifth day from his attack. (*Neal's Life of the Duke of Kent.*) Had his feet been put in hot water, or even kept before the fire, *until his circulation was thoroughly established*, no serious disease would have followed, for the Duke had an excellent constitution. I am also firmly persuaded, both from theory and practical experience, that the congested state of the lungs would have yielded far more easily to hot fomentations, applied over the chest and abdomen, than to the loss of between seven and eight pounds of blood. When a young man, Dean Swift contracted a deafness from sitting on a damp seat, as we are informed by Mr. Wilde, of Dublin, who says that for many years he laboured under cerebral congestion. I also knew a lady who lost her hearing by sleeping between two

ter what it is in summer in the City of London—while from pneumonia, asthma, whooping-cough, croup, bronchitis, influenza, pleurisy, tonsillitis, laryngitis and hydrothorax, the difference has been much greater; and nearly 25 per cent. greater from all diseases.

If then it be true, that in a population of 15,441,735 in England and Wales, the annual mortality is 105,199 from diseases of the respiratory organs, it is fair to conclude, that in the whole of Europe, with a population of 230,000,000, the annual mortality is 1,566,907 from maladies of the same class. For if they be less fatal in Italy, Greece, Spain and Portugal, than in

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open windows one summer night, which brought on acute ear-ache and almost entire deafness. The last illness of the celebrated William Pinckney, of Maryland, originated from a cold brought on by sitting up until four o'clock in the morning, in a cold room, reading the "Pirate," just then published. The greatest poet of the nineteenth century also lost his life in the full vigour of his faculties, from exposure to a heavy shower of rain, on the 10th of April, 1824, and by remaining for some time in an open boat with his wet clothes on. Soon after this, he was attacked with shivering, languor, pains in the head, back and limbs, followed by a low fever,—for which he was bled twenty ounces on the 17th, and the operation repeated twice the next day, followed by faintness, delirium, coma, cold sweats, and death on the 19th. (*Moore's Life of Byron.*)

Now I appeal to the common sense of all intelligent men, whether immediate recourse to the warm bath, surrounding the patients with bottles of hot water, or bags of hot salt, would not have prevented the chill, and consequently the fever or inflammation, that carried off these illustrious individuals? And whether, in the case of General Washington, the immediate application of hot fomentations to the throat, with the free use of hot gargles, would not have overcome the torpor of the capillaries lining the larynx, and thus have arrested the disease in embryo?

Great Britain, the case is otherwise in Russia, Sweden, Norway and Denmark, where it was estimated by the Chevalier Edelcrantz, that 75 per cent. of all the diseases are owing to the immediate agency of cold.*

But although a large majority of diseases are brought on by the influence of cold, the long continuance of an elevated temperature is still more fatal to the human race, by generating fever, dysentery, diarrhœa, hepatitis, gastritis and enteritis—all of which belong to the same class, and are modified effects of the same mor-

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* It was observed during and after the disastrous retreat of the French from Moscow, that paralysis, deafness, loss of vision and apoplexy were frequent effects of exposure to intense cold, which is so well known to be the cause of rheumatism, that patients affected with it have been called weather-guages. It is truly observed by Bright and Addison, in their recent work on the *Practice of Medicine,* that apoplectic and hemiplegic patients are occasionally affected with pains in the limbs or side, resembling the rheumatic and neuralgic affections arising from exposure to a current of cold air; that the first distinguishable effect of such exposure is often a paralysis; that in other cases, lumbago terminates in paraplegia; that exposure of the face sometimes causes neuralgia, and at other times mere paralysis without pain. (*Page* 576.) Nor is there anything surprising in all this, when we reflect, that a great reduction of temperature in any part of the body is attended with the loss of sensation and motion. It has also been shown by Tulloch's Reports, that cutaneous diseases are far more prevalent in cold than in hot climates. And the fact has been unknowingly established by the celebrated quack, Priesnitz, who causes his patients to remain from fifteen minutes to an hour, or more, three times a day, sitting in a bath at 60°, which in a few weeks causes the skin to be covered with eruptions, boils or abscesses that sometimes discharge daily several glasses of matter, which is regarded as a critical evacuation of bad humours. (*Hydropathy,* by Claridge, pp. 118, 125, 196.)

bific states of the atmosphere. We have seen that malignant fever, and diseases of the abdominal viscera, are far more prevalent and fatal in the tropical portions of Africa, Asia and the West Indies than in the warm climates of southern Europe or the United States, where they are also more common and violent than in the temperate and higher latitudes.* According to Humboldt, whose statement is confirmed by the Reports of Tulloch, the yellow fever of the West Indies is never produced at an elevation of 2500 feet above the level of the sea. And Dr. Caldwell asserts, from his own observations, that it never made its appearance in the United States, without a mean temperature of 80°, for the period of at least a month. (*Malaria and Temperament*, p. 63.)

The most deadly forms of remittent fever that ever afflicted mankind, have prevailed in tropical Africa, where the temperature is high during the heat of the day, (followed by cold nights,) and where the atmosphere is filled with putrid effluvia from the decomposition of organic matter; both of which diminish respiration, sanguification, secretion, nutrition and all the forces of life. Many travellers relate, that when trading caravans are overtaken by the hot simoon from the Great Desert, (which operates like a furnace

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* According to Dr. Forry, the ratio of remittent and continued fever does not exceed 3·31 per cent. of all the cases treated in the army stationed in the northern States; while in the southern States it amounts to from 18 to 20 per cent. Dysentery and diarrhœa are also far more common in the southern than in the northern States, where they prevail chiefly during summer. (See *Climate of the United States*, p. 298.)

or heated air-bath,) it causes excessive languor, thirst, prostration of strength, loss of appetite, nausea, fainting, and sometimes sudden death.* Under such circumstances, the process of respiration is nearly arrested, and the temperature of the solids is raised so nearly to an equilibrium with that of the arterial blood, that the transition of caloric from one to the other, on which the process of nutrition depends, is nearly suspended, and all the energies of life are proportionally diminished.†

When the system has been exposed for several hours of each day, for weeks, and even months, to a temperature varying from 120° to 130° in the sun, and from 95° to 100°, and sometimes 10° or 12° higher in the shade, the powers of life are so far diminished, that when the atmosphere is suddenly reduced to 70°, as during the hurricanes of the rainy season; or to

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* To avoid its fatal influence, the Arabs are in the habit of lying down, digging holes in the ground and applying their nostrils to the fresh earth. The East India papers also state, that during the month of June, 1842, the mercury stood at 110° in the shade at Jellalabad, (in lat. 26°,) and that the British soldiers dug holes under their tents, by which they obtained a temperature of 90°. No wonder that the beasts of the forest in Africa and southern India retire during the heat of the day to the thickest shades they can find, or to pools of water, where they lie panting until the cool of the evening comes on.

† Hence the great mortality which often occurs in the United States during the hottest portion of summer. The New York papers state that, from Saturday night of July the 11th, 1846, till Monday evening the 13th, the coroner of that city was called to visit the bodies of thirty-seven persons who had died suddenly from the effects of extreme heat. And it frequently occurs that the weekly mortality is doubled from the same cause.

50°, and sometimes to 42° just before sunrise, as in tropical Africa and India, chilliness comes on, with a general torpor of all the organs, obstructed circulation, a livid hue of the surface and extremities, and a deranged condition of the blood, which, being no longer duly renovated by respiration, is unfit to combine with the solids and maintain the several functions of life.* In some cases, the cold stage is ushered in with stupor, apoplexy and all the symptoms of cerebral congestion, followed by malignant fever, dysentery, cholera, hepatitis, dropsy, apoplexy or paralysis. As a general rule, fever is most prevalent and fatal when and where the difference is greatest between the temperature of day and night, *cæteris paribus*. Hence the great mortality from the plague in Egypt, where the extreme heat of the day is succeeded by cold nights.

Corresponding with the general fact, that all maladies belonging to the febrile genus are far more prevalent in tropical and warm climates than in the middle and higher latitudes, they are most fatal during the alternations of sultry heat and floods of rain, that prevail during summer and autumn, in almost every part of the torrid zone, where, at that season, they often assume the form of typhus; while it is well known, that in India and in central Africa, the cool winds of

* Hence the prevalence of liver disease in hot climates and malarious districts; for the venous blood of the bowels has to circulate through the whole capillary system of the liver, before it gets into the general circulation, to be renovated in the lungs. The consequence of which is, that when respiration, and the power of the general circulation, are very much diminished by the united influence of a high temperature and an impure atmosphere, the liver is more liable to congestion than any other part of the body.

the dry season are highly refreshing, and bring with them health, strength and a delightful flow of spirits, but often produce coughs and other catarrhal affections.

It is therefore obvious, that the surest method of preventing the diseases of hot climates, is to maintain the temperature of the body at the natural standard, by resorting to frequent ablutions with cold water, (as practised by the Brahmans and Egyptian priests,) a light vegetable diet, with pure water, sweetened with sugar, or slightly acidulated; by avoiding exposure to the hot sun, the use of all spirituous liquors, (excepting when the circulation is below par,) animal food, fatigue of body or mind, especially the chilling influence of damp night air, cold rains, &c. With such precautions, I should not fear to encounter the most fatal climate of India or Africa.* But unfortunately

* That health might be preserved in the most sickly parts of the tropical zone, would appear from an experiment performed by Captain Murray, and related by Mr. George Combe, in the *Constitution of Man.* After remaining two years on the coast of Labrador and Newfoundland, with a crew of one hundred and fifty men, Captain Murray left Plymouth on the 24th of December, 1823, for Tampico, Curaçoa, Vera Cruz and the West India islands, where the Valorous remained eighteen months without losing a man, or having one on the sick list. This extraordinary result was achieved by keeping the vessel dry and clean, which was accomplished by frequent washing and scrubbing of the decks, which were thoroughly dried by means of Brodie stoves, kept burning in the cock-pit and between the lower decks. The bedding of the men was also kept dry, and they were supplied with two extra pairs of flannel shirts and drawers, which were shifted every Sunday. Nor did he ever suffer the watch to turn into their berths with wet clothes on. In addition to all this, the men were not allowed to labour in the hot

for the greater part of mankind, their ignorance in regard to the simplest laws of life and health has ever been a most fruitful source of disease, suffering and premature death, even in the most favourable climates.

For example, there is no part of the world more favourable to health and longevity than England. But owing to the former ignorance, indolence, poverty and wretched state of the inhabitants, their neglect of agriculture, the filthy condition of the streets and houses in large towns, the country was visited by famine and pestilence forty-four times from the year 1069 to 1392, or during the space of three hundred and twenty-three years. And Mr. Farr informs us, that London was desolated by the plague twenty-four times from 1407 till 1665. He adds, that during the year 1665, 97,902 individuals perished from all diseases, and 68,596 from the epidemic.* (*Med. Almanac*, p. 178.)

Thus we perceive that during the frightful reign of ignorance and superstition, when pestilence and famine

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sun, and had their allowance of cocoa before leaving the ship in the morning, with a supply of fresh meat and vegetables, whenever they could be obtained. But they were never permitted to go on shore in the hot sun, nor where spirits were to be had. It is impossible to estimate too highly the conduct of this enlightened officer, who richly deserves a knighthood for the valuable lesson he has taught mankind.

* Macaulay estimates the population of London during that period at about 500,000. But Dr. Sydenham says, that during the plague of 1665 two-thirds of the inhabitants had retired to the country. The same author states, that the preceding winter had been extremely cold, being attended with continued frost till near the end of March, and by great mortality from inflammatory diseases of the lungs, pleura and throat.

were regarded as judgments inflicted on mankind for their sins, the mortality was often greater in the temperate climate of England, as in many other parts of Europe, than it now is in the sickly portions of tropical India and South America. In fact, there is sufficient evidence, that during the prevalence of the black death, the sweating sickness and most of the above plagues, the number of deaths varied from 13 to 30 per cent. of the whole population. But thanks to the progress of knowledge, and the various improvements to which it has led, such fatal epidemics have almost entirely disappeared throughout the temperate latitudes of the civilized world. And the value of life in most of the large cities in Europe has augmented from 30 to 50 per cent. within the last hundred years.

It is stated by M. Lafere, that in 1835, the mortality from plague was 10 per cent. of the whole population in Cairo, and 33 per cent. in Alexandria. But there is reason to believe, that when those cities shall be kept as clean, well watered and ventilated, as London is at present, or as Memphis and Thebes were during the epoch of the Pharaohs, the plague will cease there also, as the yellow fever has done in New York, Philadelphia, Baltimore, and will shortly do in New Orleans. All other things, however, being equal, the mortality from fever is greater in tropical than in warm climates, where it is more prevalent and fatal than in the middle and higher latitudes.* Nor is it less certain, that nearly all the

* Dr. Archibald Smith informs us, that the black cattle of Peru and other elevated portions of South America, cannot endure the climate of the low and burning plains near the coast, where, like

plagues which have desolated Europe, from those of Athens and Rome, down to the seventeenth century, including the late epidemic cholera, prevailed chiefly during the latter part of summer and beginning of autumn, or until arrested by frost, which puts an end to all epidemic fevers, if we except typhus,—a disease that prevails at all seasons among the poor, ill fed and badly clothed inhabitants of large towns and filthy or crowded dwellings.

Again, the continued form of fever predominates in tropical and warm climates, but remittents and intermittents in the higher latitudes, where they prevail chiefly during warm weather, and are arrested by frost. According to Dr. Forry, the ratio of cases of remittent and continued fever, treated in the army of the United States north of the Delaware, was from 2·44 to 3·31 per cent.; but varied from 16 to 18, and even 20 per cent. in the southern States. The average ratio of diseases of the stomach and bowels was 17 per cent. in New England; 25 per cent. on the Lakes; 30 per cent. in the interior stations; and from 45 to 59 per cent. in the southern States. Nor can there be a rational doubt, that all the varieties of fever are different forms of one and the same disease, modified by climate and season, states of the atmosphere, modes of living, &c. The fevers which prevail in central Africa, Egypt, the East and West Indies,

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the human species, they die in great numbers from fever, which is more malignant when they are fat, than lean. Ashmun states in his *Diary*, that at Liberia, in tropical Africa, "every scratch or puncture becomes an ulcer; and that months are often required to dry it up."

are not more different from each other than the climates of those regions. The truth is, that there are no two countries in the world in which the climate is precisely the same; nor is it probable that any two seasons are precisely alike, even in the same countries.* Hence the endless varieties of fever, which are never the same in any two places or seasons.

It has been generally supposed, that the plague of Egypt, Smyrna and Constantinople, is a radically different disease from the yellow fever of Malta, Spain, the West Indies and the southern United States. But

* It is true, that the mean annual temperature of the same place is nearly the same for long periods of time,—or at least within a very few degrees of an uniform average. At Chiswick, in the vicinity of London, the mean temperature of ten years, (1826–35,) was 50·5°; while that of 1838 was only 47·6°. But the mean of January, 1838, was 28°; whereas the average of the same month was 36° during the preceding ten years, and the minimum 10°. In 1838, however, it fell 4·5° below 0°, or 14° lower than it had done for ten years. At the apartments of the Royal Society, the mean of the year 1838 was 48·9°, or 1·3° higher than at Chiswick. According to Mr. Luke Howard, the mean temperature of London from 1797 to 1819, was 50·65°, while at Tottenham Green, four miles north from town, it was 48·8°, making the difference 1·85°. In the Third Report of the Registrar-General, it is stated by Mr. Farr, that the mean of January, February and March, 1838, was 36·3°; and 4·6° lower than during the same period in 1840; while the spring of 1841 was 4·3° warmer than that of 1839. And the summer of 1842 has been 4·75° warmer than that of 1841—making a very large increase in the products of the soil throughout the United Kingdom. In the United States, the mean annual temperature of the year at Germantown, near Philadelphia, was 49·6° in 1821, and 54·2° in 1825, making the difference 4·6°. And it is still greater during different seasons, especially when one winter is compared with others.

it has been satisfactorily ascertained by accurate observations within the last forty years, that, like yellow fever, the plague at one time assumes the form of typhus, at another time that of malignant remittent or intermittent fever, according to the locality, season of the year, state of the weather, &c.; that it is not more contagious than any other form of malignant fever; that inguinal tumors are not essential to its existence, being absent in many cases, and they are sometimes present in yellow fever.*

That epidemic cholera is owing to the same morbific constitution of the atmosphere which produces malignant fever, would also appear from the fact, that during its prevalence, it was far more fatal in tropical and warm climates, than in the temperate and higher latitudes. For example, it was far more destructive in India, Arabia, Syria and Persia, than in the colder parts of Asia; and more so in the south than in the north of Europe, where it prevailed chiefly during summer and autumn. And it was far more fatal in New Orleans, where the temperature of summer is tropical, than in New York, Pennsylvania, Maryland or any of the middle and northern States, where it also prevailed chiefly during the fever season. In the year 1832, there were 3200 deaths from cholera in

* Dr. Potter relates, that many of his patients, labouring under yellow fever at Baltimore, in 1798, had inguinal buboes. (*Med. Recorder*, No. 4, p. 581.) And Dr. Hildreth says, that many cases of epidemic fever in Ohio, in 1822, were attended with swelling of the parotid glands. Dr. Cooke also states that he has observed buboes, carbuncles and parotid swellings, in several epidemics of the United States. (*Transylvania Journal*, vol. iii. p. 567.)

London; 2330 of which occurred in July, August and September,—while in 1833, nearly the whole mortality occurred in August and September. In the course of July and August, it swept off 15,000 individuals in the City of Mexico, the population of which was 200,000; and 8253 in Havana, out of 65,000 inhabitants.* (*Lancet* of Jan. 6th, 1835.)

A still more decisive proof that cholera, dysentery and other diseases of the digestive organs, belong to the same genus as fever, is that they are convertible into each other, according to the state of the weather. As an example of this, epidemic cholera made its appearance in New Orleans in the summer of 1833, during a succession of cold and heavy rains,—after which the weather became hot and dry, when the disease assumed the form of malignant yellow fever, which continued with great violence until arrested by frost.† It is also well known, that in many other

* From the commencement of the cholera in St. Petersburg, on the 1st of June, to the 21st of July, 1848, 19,772 persons were attacked, of whom 11,068 died. The *Military Medical Gazette* also states that in the whole of Russia, from the 28th of October, 1846, to the 5th of July, 1848, the number of persons seized with the epidemic was 290,318, of which 116,658 died. At Riga, with a population of 40,000, the daily number of deaths was 100, in the latter part of July; so that, if the mortality were to continue at this rate for one year and thirty-five days, there would be no inhabitants left. In July, 1849, the mortality of St. Louis, in Missouri, was about 700 per week, in a population of 50,000. But the City Council ignorantly forbade the sale of all fruits and vegetables, which are not only good in their season, but necessary for health.

† The fact is, that blue cholera, like the worst forms of typhus and dysentery, is in most cases an undeveloped fever, or one in

parts of the United States, intermittent fever will make its appearance in June, and sometimes assume the character of malignant remittent or yellow fever, as the season advances, until there comes on a succession of cold rains, when it suddenly changes to dysentery, which continues until the commencement of frost, or a change of weather from wet to dry.

In his treatise on the epidemic cholera of India, Mr. Orton says, that in Bengal, Bombay and the Carnatic, it prevailed chiefly during the southwest monsoons, and declined during the dry season,—that like fever it followed the course of large rivers, and was most fatal in the low, moist, filthy and ill-ventilated portions of large cities. (*Page* 169.) It was also ushered in at St. Petersburg, Warsaw and Vienna, by rainy weather, according to M. Londe. And Dr. Jan-

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which the cold stage remains throughout the disease; for in all the milder cases, there was more or less fever, which often presented typhoid symptoms. What Sydenham said of dysentery, may be said of cholera,—that it is "a fever turned inward,"—or one in which respiration is so far diminished, that there is not animal heat enough obtained to produce reaction. And I have frequently observed the same thing in the worst forms of yellow fever, which, as before stated, are sometimes attended with buboes,—regarded by many as peculiar to the oriental plague. But the essential character is the same in both, which are brought on by modifications of the same causes, and require the same general treatment. Like typhus, they often terminate with diarrhœa and colliquative sweats, or transudation of the watery parts of the blood through the capillaries of the skin, stomach and bowels, as in epidemic cholera,—while it is worthy of notice, that the colour of the skin which comes on a short time before death in yellow fever, is owing to the effusion of serum through the coats of the cutaneous capillaries into the cellular tissue of the skin.

nechen says, that its fatality in Moscow was in proportion to the moisture of the atmosphere. In accordance with these facts, it has been fully established by universal experience, up to the present time, that the epidemic has almost always made its first outbreak in the lowest and dampest portion of the city attacked, as at St. Petersburg, Dantzic, Berlin, Moscow, Breslau, Warsaw, Paris, Sunderland, Carlisle, Manchester, London, and England generally. It has also been ascertained that the tracks of cholera, typhus and influenza were the same; that in those parts of London in which cholera prevailed, typhus and influenza have been equally fatal. (*Brit. and For. Medico-Chir. Rev.* July, 1848, p. 75.) Moreover, like the black death of the fourteenth century, the sweating sickness of the fifteenth, and in fact all other great epidemics, the cholera was preceded by a remarkable change in the general character of the seasons. We are informed by Dr. Foster, that the winter before it made its appearance in India, was one of unusual severity all over the northern hemisphere of the old world,—that snow covered the earth over a large portion of northern Africa, and nearly the whole of southern Europe. (*Lancet*, October 22, 1831.)

Dr. Brown further informs us, in an article contained in the fourth volume of the *Cyclopedia of Practical Medicine*, that in the summer of 1817, cholera broke out in the Delta of the Ganges, after an unusual disturbance of the seasons, with respect to vicissitudes of heat and moisture,—that it commenced in the district of Nuddea, where the whole year had been rainy,

(with a succession of thunder-storms,) and the country flooded with water.*

Dr. Billing maintains with Mr. Orton, that cholera is essentially a febrile disease, whether intermittent, remittent or continued,—that it is a modification of the black death, the sweating sickness, the plague described by Sydenham, and subsequently by Frank,—that whoever has had much experience in ague, has seen all the modifications of cholera; the cold stage with spasms, corresponding with the convulsions of cholera; the nausea and diarrhœa of ague, corresponding with the vomiting and purging of cholera; the blueness of the skin, low pulse and shrunken features of ague, corresponding with the general stagnation of the blood and prostration of strength in the *blue* cholera; finally, the passage of ague into continued fever, a frequent termination of cholera. And so general is the depression of temperature in typhus, that Dr. Billing objects to the hot stage as essential to its existence. (*Principles of Medicine*, pp. 216, 228, 230.)

Like the black death, the sweating sickness of 1485, (described by Dr. Caius,) the algid fever of Alibert, the cold plague of the United States and the lowest

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* In his account of the epidemic which visited St. Petersburg in 1848, Dr. Adam Crawford says, that the latter part of May and the whole of June were remarkable for rapid and frequent changes of wind and temperature, the thermometer falling from 84° and 90° to 40°, and even 32°, in a few hours, attended with thunder-storms. Dr. Müller states, that rain fell almost daily, the heavens were gloomy, the evenings foggy, and the sun was seldom visible. (*Report*, p. 5.) He adds, that the exciting causes were exposure to cold, the depressing emotions and imprudent diet.

forms of malignant typhus, epidemic cholera was ushered in with impeded respiration, coldness of the breath, surface and extremities, which felt like the back of a frog. And the temperature under the tongue was often 20° below the natural standard. As might naturally be supposed, the power of the heart was greatly reduced, and the circulation through the lungs so much diminished, that the blood was no longer renovated by respiration, but became dark and grumous, even in the arteries,—causing a livid hue of the skin, with a suspension of the nutritive process and of all the secretions.*

Owing to the cessation or great diminution of the formative process, the cohesive power of the capillaries is so far weakened, that the serous or watery portion of the blood exudes through their coats into the stomach and bowels, producing what has been called the rice-water discharges;† (which have sometimes

* From what Dr. Von C. Müller says of the cholera as it appeared at St. Petersburg in 1848, it would appear that in many cases the motion of the blood must have been suspended when the algid stage reached its highest point, as large coagula of fibrin or of oily clotted blood were frequently found in the heart after death.

† The rice-water discharges were found to consist chiefly of albumen, serum and salts of the blood, which contained a much larger proportion of red corpuscles, than in health,—not because richer in organic matter, but because deprived of its more fluid constituents; for it was so far disorganized that it refused to coagulate, and presented the appearance of a black grumous mass, like semi-fluid tar. On the supposition of Dr. Stevens, that the worst symptoms of cholera were owing to a loss of the saline constituents of the blood, and to the extreme coldness of the patient, the plan was adopted at one time, of injecting into the veins mu-

amounted to more than fifteen quarts from one individual in twelve hours;) and when it percolates the cutaneous capillaries, causing the cold sweat which marks the latter stages of most diseases. Like the hæmorrhage from the gums, nose, ears and anus, during the latter stages of typhus and other malignant diseases, or the vibices of spotted fever, such effusions always indicate a broken-down condition of the solids and a disorganized condition of the fluids. The truth is, that epidemic cholera affords an example of all the varieties of fever in their most malignant forms; for they are all ushered in by diminished respiration, a reduction of temperature, stagnation of the blood, with a loss of its vital properties, prostration of strength, insensibility and derangement of all the functions.

The primary and leading symptom of cholera is a great and sudden reduction of temperature. According to Mr. Orton, and many other writers on the dis-

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riate and carbonate of soda, in the proportions of two drachms of the former and two scruples of the latter, to about four pounds of water, at the temperature of from 108° to 110°. Dr. Pereira informs us, that a medical gentleman injected eight pounds of this solution into the veins of a patient in half an hour,—in another case, thirty-one pounds in the course of fifty-three hours,—and in another case, forty pounds in twenty hours,—that the process was followed at first by a revival of the pulse, (as might be supposed from the warmth imparted by so much water at the temperature above stated,) but soon after by death. Nor is this very surprising, after the experiments of Magendie, who found that the injection of an ounce of carbonate of soda into the veins of healthy dogs, induced languor, coma, fever, convulsions and death, in from two to three days.

ease, "the generation of animal heat almost entirely ceased," the breath, tongue and whole body became cold, the blood viscid and dark coloured, even in the arteries, the surface livid and all the secretions suspended.* It is therefore evident, that the first step to be taken in the treatment, is to raise the temperature of the patient to the natural standard, by which the heart would be enabled to restore the circulation through the lungs, and thus renew the vital properties of the blood, on which all the healthy functions of the body depend. For it has been often observed, as in cases of suspended animation, from remaining some minutes under water, that blood cannot be obtained until the circulation is revived by placing the patient in a hot bath, or by the application of dry heat.

Now if it be true, that the first link in the chain of morbid phenomena which constitute epidemic cholera, is a loss or deficient supply of animal heat, what can be the use of the lancet, emetics, purgatives and the injection of saline solutions, without restoring the natural temperature and circulation of the body? It is true that respiration is diminished by a continuous high temperature of the atmosphere. But it is still more diminished during the languid state of the cir-

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* Yet there are cases recorded, in which the temperature of the stomach and other internal organs, soon after death, was several degrees above the natural standard,—doubtless because nearly all the caloric obtained by respiration was confined there instead of being distributed throughout the body, and employed in the nutritive process. Nor is such a result inconsistent with the well-known diminished supply of animal heat by breathing, as will be shown when I come to treat of fever.

culation that attends the cold stage of all diseases, and should be restored by artificial warmth, which promotes the flow of blood through the lungs, the chemical function of which is augmented by the warm bath, in all cases of feeble circulation and coldness of the extremities.*

* The reason why it has been supposed by some experienced physicians, that the general coldness of the body in cholera cannot be overcome by the application of external warmth is, that it is often neglected until the circulation is nearly suspended, and the blood is reduced to a thick, grumous and tenacious mass, owing to the loss of its watery or serous portion. Under such circumstances it is exceedingly difficult, if not impossible, to re-establish the circulation throughout the capillary vessels of the lungs and general system; without which all efforts to maintain the natural temperature of the body by respiration must be unavailing. And even if this could be done, the deranged condition of the blood, after the loss of from ten to twenty pounds of serum renders it unfit to perform its vital office of nourishing the tissues. But if the body be raised to its natural temperature before the stage of congestion and suffocation has arrived, by hot applications to the skin, active frictions and repeated hot drinks, respiration, circulation and the nutritive properties of the blood, may be easily restored, by which the effusion of serum into the bowels, the spasms, vomiting and purging, will be checked. Until this is done, the application of cold, whether to the surface or internally, and whether in cholera or congestive fever, is absolutely pernicious, and can only hasten the death of the patient. In its early stages, cholera readily yields to aromatic stimulants, opiates and other astringents, provided a free circulation of the blood is maintained, which is the grand desideratum. *It is owing to the stagnation and consequent denaturalization of the blood, that the secretion of both bile and urine is arrested.* It has been often observed, that all the essential symptoms of cholera asphyxia may be produced by loss of blood, which, in a pathological point of view, is nearly the same thing as a failure in its circulation; for whenever the blood ceases to move, it ceases to nourish and vitalize the solids. The

During the existence of cholera in Germany, the papers gave an account of two salt-boilers who were attacked with the disease, and given over as hopeless by the attending physician. But the superintendent of the establishment observing that they were extremely cold, resolved on trying the efficacy of putting them in a bath as hot as the hand could bear. The consequence was, that a few minutes after he placed one of them in the bath, his skin changed from purple to a bright red colour, when he began to take deep inspirations, which increased in frequency as the circulation revived. He soon afterwards recovered his senses, and observed how very delightful his feelings were. The same plan was then pursued with the other patient, attended with similar results, and both speedily recovered without any other remedies. All the phenomena of physiology demonstrate, that the salt-boiler employed the very best possible remedy, by availing himself of the agent or principle on which all the operations of life and health depend. It is also stated by Dr. Caius, that the most effectual method of treating the sweating sickness, which in several respects resembled the blue cholera, was *to ply the patient with hot drinks, and cover him well with blankets, until the circulation was restored,* when the cold sweats diminished, and the powers of life gradually rose.*

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great thirst which generally attends the disease is doubtless owing to a loss of the serous portion of the blood; which should be restored by warm or hot drinks, if the temperature of the body be below the natural standard.

* A similar treatment of cholera has been pursued by Mr. Hill, (a surgeon attached to the Peckham Hospital, near London,) who

It has been shown by M. Quetelet, that in plague, cholera and epidemic fevers of all descriptions, medical treatment is generally of little avail. And it must be admitted that we know very little in regard to the peculiar nature of the remote cause on which the specific character of each depends. Nor is it probable that a knowledge of what constitutes an epidemic state of the atmosphere would enable us to prevent its occurrence, unless we could regulate all the meteorological changes and revolutions that make up the phenomena of climate and season. It has been repeated a thousand times, that the nature of malaria is a profound mystery. But if it be the result of vegetable and animal decomposition, it must consist of some one or more of the combinations of organic matter in the gaseous state, such as carbonic acid, carbonic oxide, carburetted hydrogen, phosphuretted hydrogen, sulphuretted hydrogen, ammonia, chlorine, cyanogen or some other gaseous product capable of being sub-

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placed his patients between very warm blankets, gave a glass of brandy in hot water at short intervals, with sugar and spices; applied friction with hot flannel and bags of hot bran to the whole surface of the body. He says that in this way he cured all his patients. Dr. Samuel A. Cartwright, of Natchez, ordered when first called, a dose composed of ten grains camphor, twenty of red-pepper and twenty of calomel, in powder or pills; then to strip the patient and rub him effectually with some stimulating ointment by as many hands as could have convenient access, until the medicine operated. His object was to restore warmth to the surface, and to arouse the torpid circulation, by friction and rubefacients. I cannot however agree with Dr. Cartwright, when he attributes the cure chiefly to the operation of calomel on the liver, accelerated by the camphor and red-pepper. Without arousing the circulation all remedies are useless, if not prejudicial.

jected to chemical analysis. And it will be seen hereafter, that all the mephitic gases diminish the process of respiration, reduce the temperature of the body, and thus tend to produce a chill, by which nearly all diseases are ushered in,—in short, that their influence is to vitiate the nutritive properties of the blood, and diminish all the energies of life.

But although we may not know precisely whether malaria depends chiefly on the agency of carbonic acid and vicissitudes of temperature, or some other yet undiscovered effluvia, in conjunction with heat, cold and moisture, we can clearly distinguish the manner in which it operates, and the effects it produces on respiration, sanguification, secretion, nutrition and all the vital functions. Whether generated in large cities, confined dwellings or marshy districts, its morbid influence is essentially the same, modified, however, in all cases, by climate and season, being always more concentrated and malignant where the temperature is highest, *cæteris paribus*. And whether cholera be contagious or not, like typhus, yellow fever and plague, it is generated by foul air, bad diet, filth, cold, moisture, fatigue and the depressing passions, where none of them before existed.

In the large towns of Great Britain, typhus fever is sometimes more fatal during winter than summer, because the want of sufficient clothing and fuel among the poor induces them to block up every chink and aperture by which the carbonic acid exhaled from the lungs of many individuals, occupying the same room, is prevented escaping, and fresh air from entering,

until the air becomes exceedingly noxious. And it is certain that, during hot weather, fever is often produced by the exhalations of men in previous good health, when thickly crowded together in prisons, transport-ships, barracks, workhouses and the confined dwellings of large towns. At the same time, it is still more certain, that fever is often produced by cold and vicissitudes of temperature alone, without the influence of malaria, or any other cause, as might be exemplified by innumerable cases.

From the foregoing facts and observations, it must be evident, that the diseases of mankind obey the same laws which govern all the other phenomena of nature. If the vast and extremely complex science of meteorology were thoroughly understood in all its multifarious details, we should be able to comprehend why one season differs from another in temperature, direction of winds, and quantity of rain, in any given place; and to predict those now mysterious revolutions of the atmosphere which seem to return at certain periods, as shown by the myriads of insects that appear in many parts of the world, at intervals of seventeen, thirty, or more years. We should then know why epidemics prevail over continents, and sometimes a whole hemisphere, for one, two, or more seasons, and then disappear, or assume a different type,—why the black death differed in some respects from the sweating sickness, and the blue cholera from both, in other respects. What medical authors term *an epidemic constitution of the atmosphere,* is a mere cloak for ignorance of the various physical changes that mark the course

of nature.* To refer it to the influence of comets, *telluric* emanations, and other occult causes, is no better than the idle dreams of astrology.

We are told by medical authors, that fever, and many other forms of disease, are generated by *malaria.* But they have never yet informed us what malaria is, nor how it produces intermittent fever in one case, remittent fever in another case, typhus fever, yellow fever, plague, cholera, dysentery, diarrhœa, &c. in other cases. This much, however, is certain, that it proceeds from the decomposition of dead organic matter, the principal results of which are carbonic acid and water, with very small proportions of carburetted hydrogen, sulphuretted hydrogen and phosphuretted hydrogen. But it is still undecided whether malaria depends on a greater abundance than usual of carbonic acid, or of some other gaseous emanation.

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* The character of an epidemic often depends on the character of the previous year or season, which, if unfavourable, diminishes the amount or impairs the quality of the crops. It would be interesting to know what connection there was between the disease called the *rust,* which destroyed vast quantities of wheat in Ohio, Indiana, Missouri and other parts of the west, in 1849, the late epidemic so fatal in those States, (especially in Cincinnati and St. Louis,) and the general character of that year. It has been often observed that influenza, (which is only an aggravation of ordinary catarrh,) is followed by typhus, cholera and other epidemics, to which it doubtless predisposes by diminishing respiration, sanguification, nutrition and all the forces of life. It has been observed, that cholera is no more than the common disease, diarrhœa, developed to a monstrous form by a peculiar state of the atmosphere,—an accumulation of moist exhalations, with sudden changes of temperature,—and which, in the early stage, readily yields to aromatics, opiates and other astringents.

That malaria is not carburetted hydrogen would appear from the fact, that in coal mines, where it is evolved in large quantities, ague is a very rare disease, but is very prevalent in low, damp and foggy situations, especially during autumn, when the debilitating heat of summer is succeeded by cold nights and mornings. From which it might naturally be inferred that *vicissitudes of temperature are essential to a malarious constitution of the atmosphere.* And notwithstanding the assertion of Dr. Caldwell, that carbonic acid does not exist in unusual quantities in malarious districts, *it is certain, that of all the morbific exhalations from decaying vegetable and animal matter, it is by far the most abundant; and that when accumulated in large quantities, it is capable of producing the most fatal forms of fever.*

For example, it is recorded in several works of high authority, that in the year 1775 one hundred and forty-six British soldiers were shut up in a dungeon called the Black Hole of Calcutta, which was eighteen feet square, open to the west only by two small windows, that were strongly barred with iron, and from which they could receive but a small supply of fresh air; that in the course of one hour, or at nine o'clock in the evening, respiration became difficult, followed by raging delirium, and before eleven o'clock, by the death of about fifty men. At six o'clock in the morning, only twenty-three remained alive; and what deserves our special notice is, *that in the course of a few days, nearly the whole of this small remnant died from putrid fever, resembling the worst forms of typhus.* But I have already stated, that typhus, and other malig-

nant forms of fever, have prevailed to a frightful extent, in crowded ships, prisons, barracks, workhouses, hospitals and the confined dwellings of the poor in large towns.*

Should it be objected, that the fevers generated in such places may be owing to noxious effluvia arising from the decomposition of various species of filth, I answer, that *carbonic acid is the principal result of all vegetable and animal decomposition, whether in open marshy districts, or in crowded and ill-ventilated dwellings.* We are also informed by Dr. Percival, that a gentleman's servant in Liverpool, after being exposed for some time to the fumes of burning charcoal, while cleaning plate in a small room, the door and windows of which were closed, was seized with shivering, drowsiness, stupor, nausea, pains in the head, back and limbs, followed by thirst, dry skin and fever, that continued for two days, when he gradually returned to his former state of good health. (*Medical Essays*, vol. i.

* Dr. James Johnson also informs us, that two men were suddenly attacked with rigors, faltering pulse, great debility, nausea, oppression of the precordia, twitching of the muscles, a muddy appearance of the eyes, dimness of sight, headache and low fever, succeeded by clammy sweats, hæmorrhage from the gums, petechiæ, a bubo in the right groin of one man, and in the axilla of the other man, after being exposed while in good health to putrid effluvia from the grave of a man who had been buried three months, near the City of Canton, in China, and which they unknowingly opened when digging a grave for one of their comrades. The one died on the fourth and the other on the fifth day after their attack. (*Trop. Climates*, p. 70, 6th ed.) It is therefore evident that all the symptoms of plague and the most malignant typhus, may be generated immediately by carbonic acid and other gaseous animal effluvia, when sufficiently concentrated.

p. 331.) It is therefore impossible to deny, that carbonic acid alone is capable of generating fever, which varies in its character according to the time of exposure, the amount inhaled in a given time, the constitution of the patient, &c.; that when greatly concentrated, as in the Black Hole of Calcutta, crowded ships, jails, barracks and workhouses, it produces all the symptoms of malignant typhus, such as coma, delirium, subsultus tendinum and a dissolved condition of the blood, especially in persons already predisposed by the depressing passions, want of suitable nourishment, clothing and exercise.

It is maintained by Bancroft, Caldwell and others, that if carbonic acid were the cause of fever, it ought to be produced in cases of exposure to the atmosphere of crowded assemblies, and all places in which it is more abundant than in the open air. To which I answer, that many individuals of delicate constitution are actually predisposed to catarrh, pneumonia, phthisis, rheumatism and fever by remaining for only two or three hours in crowded and ill-ventilated churches, in which respiration is seriously diminished, and all the functions of life impaired, as shown by the languor, drowsiness, headache, and even syncope, induced in some cases. Nor can there be a doubt, that such exposure, for a sufficient length of time, would greatly impair the vital properties of the blood, and so far derange the nutritive process as to induce all the symptoms of malarious fever.

I therefore appeal to the candour of all enlightened minds, whether it is not more in the spirit of true science, to ascertain the influence of carbonic acid, and

of all other gaseous emanations which are known to arise from the decomposition of dead matter, than to seek for the nature of malaria in some mysterious and hypothetical condition of the atmosphere about which nothing is known? And whether *vicissitudes of temperature* do not constitute a still more important condition of what is termed malaria, than even carbonic acid or any other mephitic gas? For it is certain, that in hot climates and seasons, exposure to fatigue during the heat of the day, and to the cool, damp air of night, are by far the most common exciting causes of fever, the malignity of which is in proportion to the elevation of temperature where it prevails, *cæteris paribus*. Sir James Clark observes, that a person may sleep with perfect safety in the centre of the Pontine Marshes, by having his room kept well heated by a fire during the night. But he should guard no less against the excessive heat of the day, than the chilling dampness of evening fogs, which weaken the circulation and predispose to fever.

CHAPTER IV.

ON THE AGENCY OF EXTERNAL TEMPERATURE IN PRODUCING HYBERNATION AND SUSPENDED ANIMATION.

"In the multitude of books there was nowhere comfort or knowledge, but vain promises, abuses and many errors. The cup of sloth hath tainted the schools with drowsiness, every one being more willing to assent, than to search carefully. I therefore considered within myself, that the art of healing was a mere juggle." —Van Helmont.

Dr. Roget maintains, in a treatise on Animal Physiology, contained in the *Library of Useful Knowledge*, that "Hybernation is a provision of nature to preserve animals from the effects of a temperature that would be fatal to them." And Dr. Marshall Hall observes, in an article on Hybernation, contained in the *Cyclopedia of Anatomy and Physiology*, that "the lethargy of animals is not the effect of cold, but is a physiological condition of the system, *which differs from ordinary sleep only in degree;*" and that "the true spinal or excito-motory system of nerves," (to which he refers the irritability or contractility of the muscles,) "*retains all its energies.*" What is still more remarkable, he maintains that "*the irritability of animals is inversely as the quantity of their respiration, being greater in reptiles and fishes than in mammalia, and least of all*

in birds; while in hybernating animals it augments as their respiration diminishes."

In accordance with the foregoing strange and unexplained doctrines, it is maintained by Dr. W. F. Edwards, in his work on the *Influence of Physical Agents on Life,* translated by Hodgkin and Fisher, that "the degree most favourable to life is a cold temperature." (*Page* 89.) And he adds in another treatise, contained in the *Cyclopedia of Anatomy and Physiology,* that "in cold-blooded animals, *the vitality of the nervous system is always greater than in such as are warm-blooded;*" that among reptiles and fishes "*the maximum of vitality corresponds to the depth of winter, and the minimum to the height of summer.*" (Vol. ii. p. 674.)

Dr. Edwards seems to have arrived at these conclusions, so adverse to all experience and sound observation, from finding that frogs, toads and salamanders were capable of living longer under aërated water reduced below the temperature of 50°, than when at 100° and upwards; for example, that when frogs were confined under water of the Seine at 50°, they lived from 5h. 50m. to 6h. 15m.; and that when kept under water cooled to 32°, they lived from 6h. 7m. to 8h. and 18m. But when the water was raised to the temperature of 72°, (that of the air being 68°,) they continued alive from 35m. to 1h. 10m. When raised to 90°, they died in from twelve to thirty-two minutes; and when raised to 108°, they never lived above two minutes. He also found that frogs could live in a vessel containing seventeen and a half pints of aërated water, when changed every day, from the 4th of December till the 25th of February; showing that they are really am-

phibious at temperatures from 32° to 51°. He further ascertained that fishes live much longer in water deprived of air, at temperatures below than above 50°. (*Influence of Phys. Agents*, p. 17.)

The above experiments prove only, that when the circulation of frogs and other batrachians is partially suspended by cold, they require less air to maintain a *low degree of vitality*, than when the circulation is increased by placing them in a higher temperature. As a proof of this, Dr. Edwards himself informs us, that frogs lived twice as long under water at 50° on the 23d of November, as when immersed in water of the same temperature during summer—showing that when the activity of their functions is greatly diminished by the coldness of approaching winter, there is air enough in water to support their feeble vitality for a long time; but that when their circulation, respiration and general activity are augmented by the higher temperature of summer, they require more air than water contains; therefore die in a much shorter time, and, perhaps, in two minutes or less, when confined under water at 108°.

In like manner, it is evidently owing to the torpid state of the circulation in reptiles, fishes, worms and zoophytes, that they live so much longer in vacuo and the mephitic gases,* or when greatly mutilated, than warm-blooded animals; and that even the latter re-

* Spallanzani kept a marmot, in the torpid state, immersed for four hours in carbonic acid, without its suffering any injury. Dr. M. Hall also kept a torpid bat under water sixteen minutes, and a hedgehog twenty-two and a half minutes, without any detriment to either.

quire but little air to support a low degree of vitality, when reduced to a state of torpor by external cold. Hence it is, that frogs remain for weeks, and even months under water, (which contains only about three per cent. by volume of air, according to Humboldt,) during winter, or so long as the mean temperature of the ponds and marshes in which they reside is below 50°.

Dr. Edwards performed some experiments on frogs and salamanders, which led him to suppose that they are capable of living in aërated water at temperatures below 50° by *cutaneous respiration;* because when strangled by placing a ligature around the throat, and placed in a receiver containing atmospheric air, they remained alive from one to two hours; and when taken out of the vessel, it was found to contain a sensible quantity of carbonic acid. He further states, that when the heart of salamanders was removed by excision, they lived from twenty-four to twenty-six hours in the atmosphere, but only from eight to nine hours when immersed in cold water at the same temperature;—that when the lungs of frogs were extirpated, they lived from one to five days in the air, but died in from eight to twelve hours when immersed in water at the same temperature. He therefore concluded, that air exerts a vivifying influence on the blood and nervous system, independent of the lungs and general circulation. But he seems to have overlooked the fact, that owing to the greater conducting power of water, it abstracts the vital heat from animals more rapidly than air. From all the foregoing facts and observations, it is obvious, that the *duration*

of life in animals after respiration has ceased, is inversely as the quantity of their life, and the general activity of their functions.

In the first chapter of this book, it was shown that in birds and all the more active mammalia, respiration is augmented by cold, if not sufficient to retard the circulation. But we shall find that among insects, reptiles, and even the lower orders of warm-blooded animals, it is diminished by a low temperature; and that whenever it falls below 52°, or the point at which the growth of plants is arrested, all the functions of life become languid, or entirely suspended. For example, it was found by Spallanzani, that bees and other insects consume three times more oxygen at 70° than at 36°; and similar results were obtained by Treviranus. Owing to the large extent of radiating surface, compared with the actual size of the body, whenever the surrounding air becomes cold, as on the approach of winter, they lose caloric more rapidly than it is gained by respiration, notwithstanding the great activity of that function during summer.

It has been observed by Saissy and others, that in the bat, dormouse, hedgehog, marmot and other warm-blooded animals of the lower class, respiration is diminished by a low temperature, by which that of their own bodies is greatly reduced. And that this is owing to the imperfect development of their lungs, would appear from the experiments of Saissy, who found that when a marmot was surrounded by a freezing mixture at 14°, its temperature fell from 95° to 41°; and that of a bat from 93° to 57° in one hour, when placed in air reduced to 33·80°; but when a Guinea

pig was submitted to the same experiment as the last, it lost only 3°. (*Recherches Experimentales sur la Physique des Animaux Hybernans.*)

In accordance with the above facts, it has been proved by the observations and experiments of Pallas, Spallanzani, Hunter, Jenner, Reeve, Prunelle and others, that in the middle latitudes of Europe, hybernating animals become frozen at temperatures of 10°, 14° and even 26° F. This was observed by Dr. Jenner, in the case of a hedgehog, in the comparatively mild climate of England. Spallanzani also states, that in the still milder climate of Italy, life is so far diminished in the bat and dormouse, that digestion, circulation, secretion and even *irritability*, appeared to have ceased entirely; that no change whatever could be observed on placing them *in vacuo*, or the mephitic gases; and that they no longer responded to the stimulus of electricity. What then must be the condition of such animals during winter in the higher latitudes of Asia and America, where the mercury falls from 40° to 70° lower than in England and Italy? Yet, it is a well-established fact, that after undergoing this severe and long refrigeration, they are annually restored to life by the returning warmth of spring. How are the foregoing facts to be reconciled with the assertions of Marshall Hall, Dr. Edwards, and all those physiologists who regard "the lethargy of animals during winter as a condition of the system which differs from ordinary sleep only in degree?"

That hybernation is owing to cold alone, would appear from the fact, that neither in plants nor animals does it ever occur in temperate latitudes until the

approach of winter, if we except the torpor of the tenrec, the serpent and some other animals within the tropics, caused by excessive drought and the evaporation of their fluids,—for the same reason that grass and many other succulent plants wither and die during summer in all parts of the world. And as vegetation may be kept up during winter by artificial warmth, so has it been found, that the dormouse, squirrel and other hybernating animals, remain active throughout the year, when kept in a temperature above 65°, as in climates of perpetual summer. It has also been proved by the experiments of Spallanzani and Pallas, that hybernation may be produced in the height of summer by artificial cold. Whenever the atmosphere falls below the point at which these animals are capable of maintaining their temperature at the normal standard, the circulation through the lungs is diminished, less carbon and hydrogen are given off and less oxygen is consumed, than during the warmer months. But even in summer, respiration, circulation, secretion, nutrition and their power of locomotion, are much less energetic than in the higher mammalia.

It was at one time supposed by John Hunter, that animals might be wholly deprived of life, for indefinite periods of time, by the influence of cold, and be again restored by the gradual application of warmth. Without being able to establish the fact, he performed many experiments on the combs of cocks, the ears and feet of rabbits and other animals,—which showed that they might be completely frozen and afterwards restored to a healthy state. As might naturally be

supposed, the vitality of the blood was for the time destroyed, and the capillaries so far weakened, that when the circulation was restored they were expanded by the *vis a tergo*, and tumefaction induced, as in all local inflammations. The normal properties of the blood being in all such cases impaired, it cannot unite with the solids, until renovated in the lungs by respiration; so that the caloric usually employed in the process of nutrition, is given out in the free state, causing an elevation of temperature or local fever, which disappears as soon as a free circulation of blood is restored through the part by fomentations, poultices, &c.

But the experiments of Hunter are annually performed by nature on a grand scale, and in a far more instructive manner, in the middle and higher latitudes, where the whole vegetable world and all the lower orders of animals, including, as we have seen, many species that are warm-blooded, are reduced to a state of suspended animation for months during winter, but rise to newness of life when "the flowers begin to appear on the earth, and the voice of the turtle is heard in the land." In fact, caloric not only restores life to beings in which it had become extinct, but causes the formation and growth of all organized bodies, which could have no life without it, therefore no *excitability*, which is merely a property of life.

Will it be said that a frozen animal is not dead, but retains a small remainder of vitality in a latent state? Where then is the evidence of this, when respiration, circulation, secretion, nutrition and absorption, are suspended, and every sign of irritability is extin-

guished? However this may be, it is not true that when the functions of life are once completely suspended, they cannot be again restored, as maintained by modern physiologists. On the contrary, it is absolutely certain, that the lower species of animals may be, and have remained, in a frozen state for weeks and months, with *the aptitude to live, but without life,* until supplied with a certain amount of caloric which is no less essential to their excitability than to the action of the heart, brain, voluntary muscles, stomach, nerves, &c. It is stated by Izaak Walton, on the authority of Gesner, that some breams were placed in a pond, that became one *mass of solid ice the ensuing winter;* but that soon after it was melted by the warmth of spring, they were found swimming about in perfect health. (*Complete Angler*, p. 257.) Captain Franklin also states, that in the arctic regions, fishes from Winter Lake, froze as they were taken out of the net, until brittle as ice, and were afterwards restored to life when placed before a fire; that a carp, after being frozen for thirty-six hours, recovered so far as to leap about with some vigour. Dr. John Davy informs us further, that his brother Sir Humphrey kept leeches for several weeks in a congealed state, from which they revived in a warm room; but that when reduced to the same condition by freezing mixtures, and suddenly transferred to warm water, they all died soon afterwards, except one.

Why then, it may be asked, are there so few recoveries from death caused by cold, strangulation and suffocation, in mephitic gases? For it is stated by the managers of the Royal Humane Society of London,

that life is rarely recovered after the individual has remained four minutes under water.* But Dr. Edwards found that young puppies may be kept under water above fifteen minutes, or reduced to a state of suspended animation by cold, and be restored to activity by fresh air and warmth; that young rabbits immediately after birth, could sustain the want of air for twenty-eight minutes; when five days old, for sixteen minutes; when ten days old, for five and a half minutes; but when fifteen days old, for only two and a half minutes. Many other experiments might be adduced in support of the doctrine, that life may be suspended for a much longer time in very young animals and be again restored, than at later periods; and longer in all classes, in proportion as their vitality is less.

It is also known, that the human subject may remain for many days in a state of partially suspended animation, and be recalled to activity by proper treatment, as in cases of trance; that Elizabeth Woodcock of Impington, while returning from market at Cambridge, in a state of intoxication, was overwhelmed by drifts of snow, under which she remained for eight days and nights, but died some months afterwards from a low congestive fever, induced by that long

* According to the experiments of Mr. Erichsen, in dogs suffocated by drowning, the blood in the arteries became as black as that of the veins in about two and a half minutes, and the voluntary movements ceased in one and three-quarter minutes; but the heart continued to contract for periods of from six and a half to fourteen minutes. It would be interesting to know whether the blood coagulated before the cessation of the heart's action.

chill. It is further related by Samuel Cooper, that a French peasant named Boutillot, was lost in a snow-storm on the Black Mountains, which separate France and Spain, where he remained four days in a state of lethargy, but awoke on the morning of the fifth. (*Surgery*, p. 105.) And it is stated by Baron Larrey, that most of the soldiers who escaped death during the fatal retreat of Napoleon from Moscow, afterwards died of low fevers, attended with coma, delirium, hæmorrhages and subsultus tendinum; or were attacked with paralysis, deafness, impaired vision, neuralgia, rheumatism, dysentery and diarrhœa. It is also related by M'Nish, that sheep have remained buried under banks of snow for six weeks, in the Highlands of Scotland, and for two months in Iceland; which recovered when released from their paralyzing confinement.*

It is therefore probable, that our power of restoring warm-blooded animals, not excepting man, from a state of suspended animation, is much greater than is generally supposed. In fact, there is no assignable reason why man might not be reduced to a state of suspended animation, for any period of time, if kept at an uniform temperature, somewhat below the freezing point, and afterwards restored to life by a gradual

* It is stated in the Philadelphia *Ledger* of March 23, 1847, that on the 25th of November, 1846, twenty-six sheep belonging to Levi Martin, of Bingham, in Maine, strayed from his farm, and were buried in the snow for eighty-two days, (without any food,) when three of them were found alive, two of which recovered and did well. It would be interesting to know the temperature of these animals, and the state of their circulation when found.

supply of caloric. At the same time, there is reason to believe, that this power is confined to cases in which there has been no serious disorganization; *that when the movements of life are suddenly arrested from any cause, the blood undergoes the process of coagulation, or is so far disorganized as to become unfit for nutrition,*—for we have seen that when taken from a healthy sheep, and surrounded by a freezing mixture at 0°, it coagulated before congealing. Owing, however, to the gradual reduction of their temperature, circulation, &c. on the approach of winter, the blood of reptiles and hybernating animals does not coagulate; so that on the return of spring it recovers its fluidity, colour and power of stimulating the heart and other organs, at the same time. I have shown that after blood has been frozen, its contractility, like that of the muscular fibre, may be restored by raising its temperature. But that its organization may be seriously deranged by congelation, would appear from the fact, that after eggs have been frozen and then thawed, they lose their transparency and become opaque, (as may be seen by holding them up to the light,) and will not hatch.

In attempting to restore suspended animation, it is idle to rely on electricity, bleeding, injections of tobacco and other equally useless or pernicious remedies. The supposition that electricity promotes vegetable and animal life or removes disease, is an exploded fallacy. The managers of the Royal Humane Society have long since thrown aside the galvanic battery as a mere toy, and like sensible men, follow the indications of nature, by resorting to the warm bath, beds

heated with hot water, inflation of the lungs with fresh air and the application of bottles filled with hot water to the thorax, with a view of arousing the suspended action of the heart. Until the circulation is restored, what can be the use of the lancet, or even brandy, ammonia and other stimulants? In short, we must rely chiefly on the great conservative principle of nature in the treatment of all maladies. And they who neglect her precepts, deserve not the name of physicians.*

There are many facts recorded in the scattered annals of natural history and physiology, tending to show, that even birds may be reduced to a state of suspended animation by cold, and afterwards restored by the gradual application of warmth. For it was found by Spallanzani, that on surrounding martins with ice, they lost all sensibility and power of motion, but revived when placed before the fire. And many other highly respectable authors assert, that swallows have been found during winter in the hollows of trees, in a state of complete lethargy, from which they were recovered in the same way. Although the smaller birds have great powers of obtaining caloric from the atmosphere by respiration when in a healthy state and well nourished, many of them lose it still more rapidly

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* In the Philadelphia *Ledger* of August 26, 1851, there is an account of two ladies who, while bathing at Cape Island, got into deep water, and after being rescued remained black for several hours, without any attempt to restore the nearly suspended circulation by the warm bath, or by hot applications over the heart. Instead of this, emetics were given to expel the water they were supposed to have swallowed.

in a very cold atmosphere,—owing to the large extent of radiating surface, compared with the diminutive size of their bodies. So true is this of young poultry, that they never thrive and grow well at temperatures below 65°, but pine away gradually and die of the roup, or some influenzal disease. It is therefore probable, that the process of artificial incubation, and the rearing of poultry, cannot be carried on so well in the middle latitudes as in warm climates, like that of Egypt, where nearly 100,000,000 fowls are thus produced annually.*

It was maintained by John Hunter, that *animal temperature is an effect of the vital principle, which he supposed had the power of generating both heat and cold.* In support of his opinion that animal heat is generated by the *materia vitæ*, he observes that when a dormouse was exposed to the influence of a freezing

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* A late writer on artificial incubation, (Mr. J. Cantelo,) very justly observes, that to succeed, we must imitate the proceedings of the parent bird, which leaves the nest every day, for twenty or thirty minutes, in search of food. The eggs are thus cooled, by which the air in them contracts, and admits a fresh supply for the support of the germ. He places them under a water-proof cloth, that the upper surface may be heated, as by the body of the hen, and the lower parts remain cool; so that the loss of moisture by evaporation is less than when the eggs are heated alike all over. A current of warm water is made to flow over the incubator, by which the upper surface is kept at the temperature of about 106° F.; after which the water is made to return through a pipe to the tank from which it came. He adds, that *when the supply of heat is deficient, the legs or feet of the chickens are imperfectly formed,* as they are when the eggs are partly stale, or when hatched in ovens; but that they are often left by the hen for twelve hours, without preventing the hatch.

mixture, "it defied the cold while the vigour of life lasted, but that when all signs of life were extinguished, it became frozen." (*Trans. of the Royal Society*, vol. lxvi.) But he might have said, with more truth, that so long as a portion of its heat remained, it retained a certain amount of vitality; and that when deprived of heat, it became frozen or dead. For he admits, that "*the effect of cold is to lessen the living principle or its powers of action; and that heat is the only thing wanting to put these powers in action.*" He further maintains that temperature is the effect of vitality, because a longer time is required to congeal birds and mammalia, than reptiles and fishes, whose vitality is much lower. But we have seen, that birds generate about sixteen, and mammalia above eight times more caloric in a given time, than the same weight of reptiles; which is the true and sufficient reason why they require a longer time to be reduced to the frozen state. In support of the above argument, he found that fresh eggs were a longer time in congealing, *cœteris paribus*, than after they have been deprived of life by being frozen. But it is known to those who deal in eggs, that fresh ones are warmer to the touch, than after they have been frozen or spoiled by long keeping, and may therefore be supposed to contain more caloric around their particles. For the same reason, fresh blood requires a longer time to congeal than after it has been once frozen, and then raised to its former temperature.

Hunter was further confirmed in his opinion that "life has the power of regulating animal temperature," because he found that on introducing the bulb

of a thermometer into the urethra of a living penis, while immersed in water at 50°, it fell from 92° to 58°; but that in a dead penis it fell to 50°. He also found that when a living penis was immersed in water at 118°, with the bulb of a thermometer in the urethra, it rose only to 102¼°, and to 104° when applied to its surface, while the temperature of the water was reduced; but that when he introduced the bulb into the urethra of a dead penis, while immersed in water at 118°, it rose to 114°, without sensibly reducing the temperature of the water. Now it is obvious that in these experiments, Mr. Hunter overlooked the fact, that whenever any part of the living body is placed in a fluid medium above its own temperature, a large portion of caloric is transferred to the rapidly circulating blood and conveyed throughout the body, by which the temperature of the water is reduced and that of the body raised, as proved by the fact, that on placing the feet in hot water the whole body becomes gradually warmed. But as there is no circulation in a dead part, the caloric of the water is not carried off by the blood, and diffused through the body; therefore accumulates in the part immersed, and without much diminishing the temperature of the water.*

* According to M. Decandolle, the internal temperature of trees is the same as that of the earth at the depth of three or four feet, or so low as their roots extend; doubtless because the moisture absorbed by the roots imparts caloric to the cells and vessels of the tree, which is a bad conductor of heat. Evergreens are also preserved in temperate climates during winter, by the oily and resinous matters they contain, which are non-conductors. These views afford an easy explanation of a fact stated by Dr. Caldwell, that "snow melts sooner on living garden-shrubs than when they are

Were it not that the foregoing fallacies of Hunter have been embraced by many distinguished physiologists of the present day, I should have passed them over in silence. It is maintained by Richerand, that life has the power of generating cold, because, on applying bags of hot sand along the leg of a man whose femoral artery had been tied for the cure of popliteal aneurism, he found that its temperature rose several degrees higher than that of the sound leg when treated in the same manner. But in such cases, a limb in which the circulation is nearly suspended, becomes sooner heated than a healthy one, for the same reason that the stationary surface of the earth becomes much warmer than the waters of lakes and seas, which are in a state of perpetual motion and circulation.

In accordance with the erroneous views of Hunter, and of many others who have confounded or reversed cause and effect, Mason Good observes, that "in all degrees of atmospheric temperature which the body can endure, it preserves an equality of its own temperature." (*Book of Nature*, vol. i. p. 241.) With Sir Gilbert Blane, Dr. Paris maintains, that animal heat depends chiefly on the living principle, which has the power of regulating temperature. And Dr. Roget observes, that "man, wherever born, can go through the wide range of external temperature which lies between

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dead;" because they are not then warmed by the absorption of water from the earth by their roots. Mulder has shown, that although the ascent of sap in trees is always less in winter than in the other seasons, it is less diminished in coniferæ and other evergreens than in trees which shed their leaves in autumn. (*Chem. of Veget. and Animal Physiol.*, p. 733.)

the freezing and boiling points, without undergoing the slightest alteration in that of his own body." (*Lib. of Useful Knowledge*, Animal Physiology, p. 109.)

The supposition that animals have the power of generating cold, was long upheld by some imperfect and fallacious experiments of Fordyce, Blagden, Dobson and others, who reported that they had remained in air heated to from 130° to 260°, for ten and fifteen minutes, without the temperature of their bodies being raised more than 2° above the normal standard. (*Phil. Trans.* for 1784–85.)*

But it had been previously ascertained by Dr. Crawford, that on confining a dog in air heated to 134° for fifteen minutes, his temperature under the forearm rose from 102° to 106°; and that when placed in water at 114°, it rose from 102° to 108° in five minutes, when his respiration became hurried and distressing, his venous blood of a bright arterial hue, and his strength prostrated. (*Phil. Trans.* for 1781.)

In accordance with these facts, it has been recently shown by the experiments of Delaroche and Berger, that when surrounded with hot media, the temperature of man is raised several degrees above the natural standard; that when M. Berger remained sixteen minutes in a room heated to 188°, his temperature under the tongue rose 7°; while that of M. Delaroche rose 5·5° in seventeen minutes in a vapour bath at 120°. They further ascertained that when birds, cats,

* This power of preserving a nearly uniform temperature when exposed to a higher one, was attributed by Dr. Franklin to increased perspiration, which certainly does remove a large amount of caloric from the body.

rabbits, and other small mammalia, were kept in an oven heated to from 132° to 149° F., their temperature rose from 10° to 14° above the normal standard, when they became greatly prostrated, and generally expired under the experiments—doubtless because the temperature of their solids was raised to an equilibrium with that of the arterial blood, and the process of nutrition arrested. From a great variety of well conducted experiments, they concluded that vertebrated animals cannot remain long alive and in health, in a dry atmosphere above 113°. (*Journal de Physique*, lxiii. 207; lxvii., and lxxi.) Certain it is, that warm-blooded animals cannot remain long free from disease in an atmosphere several degrees above the temperature of their own bodies. Delaroche and Berger also found that cold-blooded animals very soon died when raised to the temperature of from 104° to 108°—corresponding with the results of Edwards, who found that frogs and other batrachians die sooner when immersed in water at 100° and upwards, than at lower temperatures.

With a view of satisfying my own mind more fully in regard to the influence of the hot and warm bath, on the temperature and circulation of the human body, I performed the following experiment on Mr. T. B. Hopkins, a medical gentleman of sanguine temperament, aged about twenty-eight years. The temperature of Mr. H. was 100·5° under the tongue, and his pulse 72 per minute. At twenty minutes after 11 A.M., he entered a bath at 110°. In five minutes, the temperature under his tongue rose to 103°, and in five minutes more, to 106°, when his pulse was 132. At

this time the bath was at 108°, in which he remained until twelve o'clock, when it had fallen to 105°, and his own temperature to 104°, when he left it. The most important fact connected with the experiment was, that at one o'clock, or an hour after quitting the bath, his temperature was 102° in the mouth, and his pulse 96. At two o'clock, (still in the bathing room,) his temperature was 101°, at which it remained until nine o'clock in the evening, when his pulse was 82.

If then it be true, that the temperature and circulation of a vigorous young man are kept above the natural standard for nine hours by remaining forty minutes in the hot bath, what might we not expect from its early employment in all cases of exposure to external cold, and before the cold stage of intermittent fever? Would it not prevent, or greatly mitigate, many forms of disease that prove fatal? And is it not self-evident, that after thus raising the temperature and circulation of the body, it is capable of resisting the influence of external cold for a longer time? Hence it is that the Russians sometimes roll themselves, while naked, in the snow, after leaving the vapour bath, which they could not do with pleasure and impunity, if not thus previously heated, by which the circulation through the lungs, and, consequently, the process of respiration, are augmented. But if much heated, a bucket of cold water should be thrown over the individual on coming out of the bath, so as to reduce his temperature to something like the natural standard.

At twenty-five minutes after twelve o'clock of the same day that Mr. Hopkins went into the bath, he noted down the results of the following experiments.

on myself. The temperature of the air was 46° out of doors, that of the mouth under the tongue was 99°, and the pulse 75, when I entered a bath at 104°. In ten minutes, the temperature in the mouth had risen to 102°, and the pulse to 88, at which they remained twenty-five minutes. The bath was then raised to 110°; five minutes after which my own temperature rose to 104°, and the pulse to 118, at which they remained for ten minutes longer, when I left the bath in a very feeble condition. After walking half a mile, and dining at three o'clock on mutton-chops, with bread and potatoes, the temperature under the tongue was 100·5° or 1·5° higher than before going into the bath, and at ten o'clock in the evening was 100°, while the pulse was 80.

I have also found, that while moderately covered in bed, the temperature under the tongue may be raised from 2° to 3° in the course of an hour or less, and copious perspiration induced, by keeping a flat bottle of hot water over the stomach. In fact, we may obtain all the benefits of the hot bath by the judicious application of dry heat, which may be employed with safety in cases of extreme debility, when removal from bed to the bath would be attended with great inconvenience, and even danger. By surrounding the patient with hot bricks, or bottles of hot water, covering him with blankets, and giving hot drinks, the circulation may be very soon roused from a state of alarming torpor. But it is greatly to be desired, that every house in Christendom should be supplied with the warm bath, which was justly regarded by the Greeks and

Romans as a prime luxury in health, and a most important remedy in disease.*

It must be observed, that when raised above the temperature of the body, water communicates to it a much larger amount of caloric in a given time than air, which is about 828 times lighter, and contains proportionally less free caloric in a given volume. Hence it is, that the human body is less heated, when confined in air at 212° for ten minutes, than in water at 115°; and that if immersed in water at 212°, life is destroyed almost instantly. And as the attraction of water for caloric is greater than that of air, in proportion to the difference of density, the human body is more chilled in five minutes when immersed in water at 32°, than when surrounded with a dry and still atmosphere at 40° or 50° below 0° for as many hours. In like manner, it is probable, that if immersed in a bath of mercury at 20° below 0°, life would be extinguished in as many seconds; for mercury is above thirteen times denser than water, and has a proportionally greater attraction for caloric.

The danger arising from exposure to a shower of

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* It was constantly resorted to by Napoleon, who generally remained in the bath two hours, during which time he was continually turning on the warm water to raise the temperature; so that often Bourrienne could not see to read the journals and pamphlets, on account of the vapour which filled the room, until the door was opened. (*Bourrienne's Memoirs.*) I have also removed very unpleasant symptoms of indigestion, brought on by sedentary habits and a languid circulation, by remaining an hour in the bath, which was raised several times to 108° F., and as often reduced to 80° by letting on the cold water, after the circulation was completely aroused.

rain, getting the feet wet, remaining in wet clothes, sleeping in damp sheets, or being out in cold or moist night air, is owing entirely to their abstraction of vital heat from the body, by which the circulation is more or less impeded, if not kept up by exercise or internal stimulants. And that moist air does it far more rapidly than dry air, will appear from the following experiments, which I performed in the summer of 1840. When a thermometer was raised to 90°, and its bulb surrounded with damp cotton wool at 68°, which was the temperature of the air, it fell 22° in seven minutes. When raised to 90° and placed in dry cotton wool, it was thirty minutes in falling to 68°. It was also found by Edwards and Gentil, that by keeping one hand immersed for some time in ice-cold water, the temperature of the other hand was reduced 11°.* Thus it is, that by exposure of the feet, hands and neck to cold winds and wet, a portion of vital heat is abstracted from the blood of the whole body, during its circulation through those parts, the action of the heart diminished, obstructions produced, and fatal diseases brought on, before we are aware of any danger.

It is a matter of the highest practical importance to comprehend distinctly why it is that the cold bath is invigorating, and in what states of the system it is indicated. We are told by medical writers, that it operates by producing reaction. But they seem to

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* Dr. Dowler informs us, that when water at 61·50° was applied repeatedly to the forehead of a patient for thirty-seven minutes, the temperature of his left hand fell from 98° to 90°, being well clothed, and the air at 68° F. (*West. Journal of Med. and Surg.*, June, 1844.)

have overlooked the fact, that in moderation it augments the process of respiration, on which reaction entirely depends, as proved by the pleasurable glow of warmth that pervades the system shortly after leaving the bath. The consequence of which is, that a greater amount of caloric passes through the body in a given time, and all the functions of life are proportionally invigorated, for the same reason that they are more active during winter than summer, and more so in temperate than in hot climates. I have also shown, that besides the influence of cold in augmenting respiration, it has the immediate effect of increasing the nutritive process, especially during very warm weather, or whenever the temperature of the solids is raised nearly to an equilibrium with that of the arterial blood. Hence the importance of cold applications to the head and general system during fever, when the nutritive process is greatly diminished.

It must not, however, be forgotten, that among young children, the aged, and all persons of delicate and feeble constitutions, the mortality is much greater in temperate climates during winter than summer,—by which we are instructed to observe great caution in the employment of the cold bath in such cases. I have had repeated proofs that the temperature of strong and active young men is reduced from 3° to 4° in about ten minutes, by bathing in the sea during summer, when the water is at 62°; and that when continued for fifteen or twenty minutes, it causes shivering, blueness of the surface, small and feeble pulse, great reduction of strength, headache, nausea,

and even vomiting in one case.* What then must be the effect of sea bathing on delicate females with languid circulation, cold extremities, and torpor of the general system, but an aggravation of the symptoms? And what can be the general effect of the cold bath on very young children but to augment the bills of mortality?

* It is therefore not surprising that Leander lost his life in attempting to swim the Hellespont in December, when its temperature must have been about 50° or lower,—nor that in performing the same feat on the 9th of May, 1810, Lord Byron should have got the ague; for its temperature could not then have been much above 60°. Since the first edition of this work was printed, a great change has taken place in the practice of the more intelligent hydropathists, who do not allow their patients to remain longer than a minute, and often not above one-fourth of a minute, in the cold plunge bath, and from one to two minutes in the half bath, according to its temperature and the strength of the patient. Moreover, if he does not get warm in ten or fifteen minutes after leaving the cold bath, it is deemed inadmissible. In his late work, entitled the *Water-cure Manual*, Dr. Shew, of New York, observes, that there are cases in which it would not be safe to apply the wet sheet cold; that injury has been done by keeping weak persons shivering for an hour when warmth is indicated; that he has effectually broken up chills by causing his patients to remain half an hour in a bath at 98° F., finishing with the cold or cool one; that he has found warm or hot applications produce speedy relief in pneumonia, pleurisy, sore-throat, pain in the back, inflammation of the stomach and bowels, in asthma, which he treats by "large hot fomentations put all about the chest," because "most excellent in relieving spasms." He states further, that "cold applications seem to increase the pain." His plan is "to foment thoroughly the whole chest and abdomen with wet flannels or towels, wrung out frequently from water as hot as can be borne, so as almost to blister the surface." And, what he thought surprising, he found that this practice "often reduced instead of increasing the force and hard-

The author was informed by a lady residing in London, who was recommended to try sea bathing as a remedy for general debility, that during the month of August she remained in the bath at Herne Bay ten minutes, when the exhaustion was such that she had to be carried out by an attendant, and did not recover her strength during the whole of that day. I have also had occasion to observe, that the temperature of several healthy young men was reduced about 2° in the course of ten or fifteen minutes, while in the Holborn bath, which was at 82°; and that in a boy ten years old, with narrow chest and feeble constitution, a thermometer under the tongue fell from 98° to 94° in twelve minutes. What is still more remarkable and worthy of attention, Dr. Bell states, in his judicious work on baths, that on the 20th of July, 1830, when the air was at 88°, his pulse was reduced from 70 to 65 beats per minute, after remaining three minutes in a bath at 90·5° F., which, he says, felt decidedly cold. I also brought on myself an illness by remaining half an hour in a bath at 80°, during the summer of 1845. The first symptoms were a stoppage of perspiration, general languor and headache, followed by a slight fever, which was arrested the following day by a hot

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ness of the pulse." But there is nothing surprising about it, for when obstructions are removed, the pulse becomes softer and slower. He adds, that he "has prescribed moderately warm baths, followed instantly by a cold or cool one, hundreds of times, apparently with the best effects." (*Pages* 102, 104 and 141.) *Finally, whenever the system is below par, the effect of heat is invigorating, until the temperature and circulation are raised to the natural standard, after which it is debilitating.*

bath. We are also informed by Dr. Edwards, that when kittens a day or two old were immersed in ice-cold water, (excepting the head,) they died in four minutes and a half; whereas Sir Astley Cooper found that a kitten six weeks old lived sixteen minutes when treated in the same way. It is therefore manifest, that during the early stages of infancy, the power of obtaining caloric by respiration is very limited; that it should be carefully preserved by warm clothing, and not idly wasted by cold bathing.

On the other hand, when the system has been exhausted by cold, over-exertion or loss of sleep, there is nothing more delightful and refreshing than the warm bath, which is peculiarly adapted to individuals of the phlegmatic temperament, and to all such as are troubled with cold extremities, torpor of the circulation, indigestion and constipation of the bowels. It is a natural mode of accelerating the functions when languid, improving the blood, relieving oppression, tranquilizing the feelings and adding to the sum of pleasant sensations, while it tends to prevent congestions and inflammations. The best temperature, in all cases, is that which is most agreeable to the feelings. Finally, the warm and cold bath are only means of adding to the body, or subtracting from it vital heat. The latter is often dangerous; whereas the former is rarely if ever so, when rightly employed.

BOOK VI.

CHAPTER I.

AIR AND EXERCISE.

"If all the capacities of all ages should unite and transmit their labours, no great progress would be made in learning by anticipations; because the radical errors, and those which occur in the first process of the mind are not cured by subsequent means and remedies. An instauration must be made from the very foundation, if we do not wish to revolve forever in a circle, making only some slight and contemptible progress."—BACON.

FROM the earliest periods of history the ancients confounded air with heat, which they regarded as the great spirit of the universe. For example, the Greek word αηρ, and the Latin *aura*, were evidently derived from אור, *aur*,* which, in the Hebrew, Phœnician, Egyptian and Chaldean languages, signified light, fire and spirit. In the treatise of Hippocrates on *Air*, he

* The "*auræ particula Divinæ*" of Cicero, Adrian and other Roman philosophers, was certainly not gross air, but what Pope very beautifully terms "vital spark of heavenly flame," which was called *aura*, because it is obtained from the air by breathing. The Latin word *spiritus*, also means air or breath, and *inspiro*, to breathe in air, from which the vital spirit is derived. Hence the origin of our English words spirit and inspiration.

maintains that an exceedingly subtle and refined spirit, which he terms αηρ and πνευμα, pervades universal space, guides the sun, moon and stars in their courses, causes winter and summer, gives life to men and all other animals. (περι Φυσων, v. vi.) He also declares expressly, in his treatise on *First Principles,* that what the ancients called αιθερ, and the Greeks θερμον, or heat, is spirit; θερμον εςι το πνευμα. (περι Αρχων. i. vii.) He further maintains, that in this universal spirit resides motion, κίνησις, life, ψυχὴ, knowledge, νόος, prudence, φρόνησις, growth, diminution, change, &c.; that a strong but invisible fire silently produces all the operations of the living body, in accordance with invariable laws.* (περι Διαιτης, book i. sec. xi.) And it is worthy of special notice, that the Latin word *anima,* meaning life, soul and spirit, is only a slight modification of the Greek word ανεμος, which literally signifies wind, or the air in motion. But that it did not denote the atmosphere alone, is evident from the manner in which it is employed by Cicero, Virgil,

* With Thales, Pythagoras, Heraclitus, Democritus and Anaxagoras, he also maintained that animal heat is derived from the atmosphere by respiration; and that it is supplied to the fœtus in utero by respiration of the mother. This rational view of the subject was rejected by Aristotle, who asserts that the *office of respiration is to diminish the innate heat of the soul in the heart.* And although Galen partly adopted this absurd hypothesis, he concludes that the principal object of respiration is to preserve the *innate heat by which we live and feel;* while he represents the air as undergoing a process like that of combustion in the lungs, from which fuliginous matter (carbonic acid?) is expired, and the blood freed from impurities. (*De Util. Respirat.,* lib. i.; *De Usu. Part.,* lib. vi.)

Seneca and many other Roman authors, who represent it as the *anima Mundi*, or soul of universal nature. Moreover, that the Greek word ψυχη did not signify air alone, but the universal spirit which "lives through all life," is equally obvious from the fact, that it is called ψυχη τȣ Κοσμȣ by many of the most profound philosophers of Greece, who maintained that the soul of man is a finite portion of the omnipresent, omniscient, omnipotent and self-active spirit, which gives motion, life and intelligence to organized beings. (BRUCKER, *Hist. Crit.* vol. i. 467–75, 1077.)

In accordance with these views of antiquity, it is remarkable, that every word in the Old or New Testament employed to represent the Supreme Creator or any spiritual essence, was derived from the manifest agency of the sun, or of light, heat and air. For example, we have already seen that *Al, El, Eli, Eloi, Elohim* and *Elion*, are all modifications of the Hebrew word אל, which signifies the Creator of heaven and earth, the material sun, and the universal spiritual fluid that pervades all things. Parkhurst also observes, what no one can deny, that the Greek word Ελωΐ, as employed in Mark, chap. xv. verse 34, is only a modification of the Hebrew אל, אלי and אלוה; that the old Greek verb εω, to be, and the word ων, being, were derived from the Hebrew word היה, or from the noun יהוה, which has been variously written by different authors, *Iao, Iei, Yeye, Yehovah* and lastly *Jehovah*, signifying the primitive essence of all existence or being.* But as the letter *o* was originally employed

* Parkhurst further states, that the Hebrew word רוח *Ruah*, signifying the spirit of God that was breathed into man when first

instead of ω, which was added to the Greek alphabet at a later period, it is evident that ων is in reality the same word as *On*, which, among the Egyptians, Phœnicians and other oriental nations, signified the sun. Hence it was, that many of the Greek philosophers employed the words το Ων and το Εν, to represent the primitive source of all existence. And it is remarkable that the words Ων and Εν are used in the first chapter of the Apocalypse, verse 8, to represent the Supreme Jehovah,—Ὁ ων, και ὁ ην, και ὁ ερχομενος,—"He who was, and who is, and who is to come."

Nor can there be a rational doubt, that the earliest impressions of mankind in regard to the existence and attributes of the Great First Cause, were acquired from beholding everywhere the creating and life-giving power of the sun,* or of that all-pervading fire which animates the infinite multitude of suns. For it is manifest that all our ideas, whether of matter or spirit,

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created, also means air or breath. He moreover observes, that it has precisely the same meaning as the Greek word πνευμα, as in John, chap. iv. verse. 24, where it is said that "God is a spirit." But he maintains that πνευμα denotes also an incorporeal *substance*, distinct from the animal soul termed ψυχη, which man hath in common with the brutes; because he is represented as consisting of soul, body and spirit, as in Thess. chap. v. verse 23, and Hebrews, chap. iv. verse 12. Yet he admits that both πνευμα and ψυχη mean breath, the air in motion, animal life, the human soul and spirit. (See *Greek Lexicon*, under these words.)

* The learned Dr. Lewis observes very justly, that when Aristotle speaks of the Prime Mover as itself immovable, he did not employ the last term to denote inactivity or quiescence, but as incapable of being moved, or of deriving its motion from anything external or antecedent; for he describes it as essentially an eternal energy. (*Platonic Theology*, p. 193.)

are prototyped in the visible and tangible operations of the universe; that they were originally derived through the senses, as demonstrated by Locke, and by the simple method of tracing all words to their primitive signification; that there is no foundation in either nature or revelation, for the doctrine of Kant and other metaphysicians, that our ideas of the Divinity, infinite space and duration, are innate in the reasoning faculties, and wholly independent of the external world, or of any material organization. On the contrary, "the heavens declare the glory of God, and the firmament showeth his handywork." (*Psalm* xix.)

The truth is, that elementary fire is the only appropriate representation of the Divinity; because it is everywhere present, and performs every operation in the physical universe. Could we travel with the speed of lightning for myriads of ages, we should still be encompassed by a boundless ocean of etherial fire, which generates every ray of light, guides the planets in their revolutions and fills them with innumerable forms of life. It is, therefore, not surprising that in so many parts of the Old and New Testament, it has been employed to represent the unknown Cause of Causes,—that it should have been declared by Moses that "God is a consuming fire," which he commanded to be kept perpetually burning on the altar of the tabernacle. (*Deut.* iv. 24; *Levit.* vi. 13.) The sacred fire was also kept burning in the Jewish temple, between the cherubim, in the holy of holies, which is often described as the special seat of the Divine Presence. And it is expressly declared in the First Epistle of John, that "God is light," chap. i. verse 5,—

a doctrine which seems to have been understood literally by many of the most distinguished fathers of the church, who maintained that the Deity is an eternal, omnipotent, omnipresent, omniscient and inconceivably subtle light or fiery spirit, as we are informed by Brucker, Mosheim and others.

But when the science of medicine shall have arrived at perfection, it will be found to consist chiefly in the art of employing those agents on which the operations of life constantly depend; or in making the vital principle itself by which the body is formed and renovated, the grand instrument of its preservation. It will then be the province of the enlightened physician to assist nature in strict accordance with her own laws. The universal diffusion of such knowledge would enable the people to prevent nearly all the diseases by which they are now afflicted, or to cut them short before they become incurable.

There is reason to hope that a time is coming when a more simple, comprehensive and practical knowledge of the physical, intellectual and moral laws of the universe, will banish disease, quackery, superstition, intolerance, discord, war and a thousand other evils, from among the nations; when the glimmering now scattered through innumerable libraries shall be condensed into a few priceless volumes; when the science of nature shall be stripped of mystery and reduced to the simplicity of self-evident axioms, about which there can be no essential difference of opinion; when the many conflicting systems of religion, philosophy and politics, that have so long distracted the world, shall be melted down into one universal code of peace

and harmony. The accomplishment of this great object is surely enough to rouse the ambition, and command the support, of all those who feel within them the vocation to benefit mankind. But it must be brought about by the patient and united exertions of men honestly devoted to the study of nature and the pursuit of truth.

When it was discovered that animal life cannot be supported without the inspiration of oxygen, physiologists began to regard this gas as the primary cause of vital action. In accordance with this view, it is observed by a writer in the *Monthly Chronicle*, that "of the two animal wants, air and warmth, the former is incomparably the more important," and that "oxygen is the life-sustaining principle of the air." (Vol. i. p. 221.) But I have already shown that the principal office of oxygen is to supply animals with caloric, without which it could no more maintain the action of the heart, stomach, brain and other organs, than it could the movements of a steam engine.

And that more caloric is imparted to the blood during the respiration of oxygen than of common air, has been proved by the experiments of many physiologists, who found that it increased the temperature of the body, the action of the heart and with it the activity of all the functions; while it enabled the system to resist the influence of external cold and that of the mephitic gases, for a longer time than common air. From some experiments of Count Morozzo, related by Dr. Thomson, it would appear that sparrows are capable of living nearly five times longer when confined in pure oxygen, than in the same quantity of atmo-

spheric air. For he found on placing them one after another in a vessel of air, (with potassa for absorbing the carbonic acid,) that the first remained alive three hours; the second three minutes; and the third one minute. But when he filled the same vessel with oxygen gas, he found that the first sparrow lived five hours twenty-three minutes; the second, two hours ten minutes; the third, one hour thirty minutes; the fourth, one hour ten minutes; the fifth, thirty minutes; the sixth, forty-seven minutes; the seventh, twenty-seven minutes; the eighth, thirty minutes; the ninth, twenty-two minutes; and the tenth, twenty-two minutes.

Dr. Beddoes also found that when one of two half-grown rabbits of the same brood, size and strength, was placed for some hours in a gaseous mixture composed of one half oxygen, and the remainder of common air, it remained lively for nearly an hour, while surrounded with a freezing mixture, although its feet were frozen; whereas the one which had breathed common air, became nearly lifeless in forty minutes, and was frozen quite dead in fifty-five minutes. In another experiment, he caused one of two kittens to respire common air, and the other a mixture of two-thirds oxygen with one-third of atmospheric air for twenty minutes; when both were immersed under water until they became motionless. On taking them out, the latter recovered in one minute and a half, and walked about, while the other was fifteen minutes in reviving, when it was scarcely able to stand. He further ascertained, that when puppies were kept in hydrogen, nitrogen and carbonic acid, until animation

was suspended, they recovered much sooner in pure oxygen than in common air. (*Considerations on the use of factitious airs.*)

At the same time, it must be admitted, that breathing oxygen gas tends to accelerate the vital functions beyond their natural speed, and therefore, like the hot bath, should be resorted to only when the temperature and vital activity of the circulation are below the natural standard, when it cannot fail to produce a salutary effect.

The nitrous oxide gas, which contains a much larger proportion of oxygen than common air, and is a more rapid supporter of combustion, also produces corresponding effects on the living body. When inhaled into the lungs, it causes the sensation of a warm glow throughout the system, an acceleration of the pulse, an augmentation of muscular power, exhilaration of spirits, with sudden bursts of laughter, increased acuteness of all the senses and a rapid succession of vivid emotions, especially in persons of the sanguine temperament. But after being breathed for some time, it produces opposite and deleterious effects, changing the blood from its previous florid colour to a dark hue, as shown by the purple colour of the face,—for it has been observed by Sir H. Davy and others, that after being breathed for some time, the greater part of its oxygen disappears, the residue, consisting chiefly of nitrogen and carbonic acid,—a portion of which is absorbed into the blood, causing confusion of the brain and sometimes syncope, with more or less derangement of all the vital functions.

It has been said, that when taken into the lungs in

moderation, after exhaustion from over-exertion, it removes at once the sensation of weakness and fatigue, without being followed by that debility which succeeds over-excitement from ordinary stimulants. There is, therefore, reason to hope that when its *modus operandi* in exalting the powers of life shall be better understood, it will be found highly important as a therapeutical agent in cases of torpor of the stomach, bowels, liver and brain, which characterize dyspepsia, hypochondriasis, hysteria, chlorosis and the cold stage of all fevers—especially in conjunction with the warm bath, moderate exercise, regimen, &c.

The quantity of respiration is greatly diminished in a rarefied atmosphere, as on the tops of high mountains. The consequences of which are, hurried and difficult breathing, small and frequent pulse, paleness or blueness of the skin, languor and prostration of strength, dimness of sight and general loss of sensibility, nausea, giddiness and symptoms of apoplexy, as observed by De Saussure when near the summit of Mont Blanc. The same effects are produced, in a still more remarkable manner, on the high mountains of India and South America, where the amount of respiration is so far diminished, that the blood is chilled to the very centre of the system. It is well known that in the polar regions life may be sustained for many hours, with suitable clothing, when the temperature is from 30° to 50° below 0°. But Dr. Gerard states, that many lives are lost in crossing the Himalayas, when the temperature is 16° F., at the height of 14,000 feet—owing to the united influence of rarefaction, external cold and exhaustion from exertion. He says, that in crossing

the Manerung, at an elevation of 18,612 feet, respiration was hurried and difficult, long before reaching the summit; that the least motion was attended with mental dejection and debility, which compelled him to sit down every few yards.

And it has been observed on the high mountains of South America, that symptoms are produced analogous to those arising from excessive loss of blood; that mules are attacked with hurried breathing and trembling of the limbs, when they stop short, or attempt to lie down, but if compelled to go on, they often fall prostrate, and sometimes die in convulsions, as if suffocated by mephitic gases. That the above symptoms are greatly augmented by exertion, is evident from the fact, that aëronauts have ascended equally high with much less inconvenience, while sitting tranquilly in their cars. When, on the 15th of September, 1804, Gay-Lussac rose in a balloon to the height of 23,040 feet above the sea, his respiration was hurried, his pulse frequent, his hands benumbed and his body chilled throughout. And it was found by Lavoisier, that Guinea pigs could live in air that contained only one-third its usual proportion of oxygen, when the carbonic acid was absorbed by pure potassa, but not without torpor and drowsiness. It is therefore probable, that men might exist at an elevation of 30,000 feet, with warm clothing, while at rest, better than at 15,000 feet in a state of exertion; for we have seen that above three times more oxygen is required during active muscular motion, than in a state of repose.

It was long ago observed by Dr. Halley, that life was supported longer in the condensed air of a diving-

bell, than on the surface of the earth. And the younger Brunel found that, on going out of a diving-bell thirty feet under water, he could remain twice as long without inspiration, as in the ordinary state of the atmosphere. After commenting on this fact, Dr. Faraday states, that on taking a few deep inspirations, he could refrain from breathing much longer than usual. But he adds, "those who wish to refrain from breathing should avoid action, *which exhausts the air in the lungs of its vital principle more quickly, and charges it with bad matter.*" (*Phil. Mag.*, third series, vol. iii. p. 243.) It is very true, that the vital principle is exhausted by exertion,—not, however, in the lungs, for *there it is obtained*, and imparted to the blood,—but in the muscles, where it is expended in *causing their action.*

Since the time of Cullen, it has been generally supposed that the mephitic gases produce disease and death, by operating as positive poisons on the nervous system, and not primarily on the blood. But carbonic acid, nitrogen and hydrogen cannot be regarded as positive poisons, for the obvious reason, that they are at all times present in the lungs. When mixed with air in the ratio of one or two per cent., carbonic acid retards the union of oxygen with carbon and hydrogen in the lungs, in the same way that it diminishes the process of ordinary combustion, which is often extinguished in places where foul air is abundant. It has been said, that air containing one one-thousandth part of sulphuretted hydrogen speedily destroys the life of birds; and that mammalia die in air containing the one hundred and fiftieth part of the same gas, which,

therefore, probably induces some change in the chemical properties of the blood. When animals are immersed in carbonic acid, or any of the mephitic gases, they die in about the same time as if confined in a vacuum, or as when respiration is suspended by strangulation or immersion under water. Under such circumstances, birds die sooner than mammalia, and the latter sooner than reptiles or fishes, because respiration is more essential to the former than to the latter, in proportion to the greater amount of oxygen which they require.

The symptoms that follow the inhalation of these gases in small quantities, or in a state of mechanical mixture with the atmosphere, are diminished respiration, attended with chilliness, imperfect arterialization of the blood, which is sent to the brain, stomach and other organs, of a dark hue, as shown by the pallid or purple colour of the skin. Under such circumstances the pulse becomes low and feeble, while all the energies of life are reduced, for the same reason that they are diminished by loss of blood, breathing a rarefied atmosphere, or by depriving the system of caloric more rapidly than it is supplied by respiration. Nor is there a more frequent cause of headache and general debility than exposure to the carbonic acid of crowded assemblies, in ill-ventilated churches and halls, not to mention the many catarrhal diseases that are contracted by delicate individuals on going out of such places into the cold night air, without sufficiently warm clothing. And it is worthy of special notice, that as the brain is supplied with a much larger proportion of blood than an equal weight of any other organ, it is sooner af-

fected by loss of blood, or by whatever impairs its vital properties, than any other part of the system—for the same reason that birds are more seriously affected by impure air than mammalia, and the latter than cold-blooded animals. For example, we have seen that in birds the circulation is so rapid, that all the blood in the system passes through the different tissues in something less than a minute, during which it gives out to the solids whatever amount of caloric it receives in the lungs, and thus returns to the state of venous blood, which, if not again properly supplied with animal heat, and its arterial properties restored, induces a general reduction of temperature, and a vitiated condition of the blood, attended with universal debility.

Accordingly, the respiration of impure air is attended first with confusion of the brain, impaired vision, ringing in the ears, pain in the head, vertigo, stupor, syncope and general loss of sensibility, or delirium. And as the contractile power of the muscles remains for some time after the voluntary influence of the brain over them is suspended, they contract spasmodically, for the same reason that convulsions are caused by loss of blood, or breathing a rarefied atmosphere. The stomach being no longer supplied with arterial blood, loses the power of digestion, and is affected with nausea or spasms, as in cholera. The pains in the head, back and limbs arise from a deficiency of vital heat and arterial blood in those parts, and are not essentially different from the aching sensation produced by exposure to intense cold, a shower of rain, getting the feet wet, or sitting in a cold room,—*all of which are owing either to an imperfect supply of the animating*

principle by respiration, or to its abstraction from the surface.

Among all the wonderful adaptations of nature, there is nothing more calculated to excite admiration than the beautiful and harmonious dependence of plants and animals on each other, for the well-being of both. In many respects, they closely resemble each other. In the first place, they are both formed of the same elementary constituents, (oxygen, hydrogen, carbon and nitrogen,) though in different proportions. They are both furnished with organs of circulation, secretion, nutrition and generation, all of which are maintained in a state of vital activity by the same principle. In other respects, however, they differ essentially.

For example, we have seen that plants have no breathing apparatus,* and depend wholly on the agency

* It is true, that in germination, atmospheric oxygen unites with a portion of the carbon contained in the starch of seeds, by which sugar is formed for supplying the germ with nourishment, until its leaves are developed. The same process takes place during the flowering or fecundation of plants, by which a portion of the farina is converted into sugar for sustaining the embryo bud,—carbonic acid being formed, and caloric evolved, as during germination. Botanists have observed, that when the sugar of flowers has been extensively rifled by honey-bees, they are rendered unfruitful. Oxygen also unites with a portion of the carbon contained in the gum and lignin of green fruits, during the process of ripening, by which sugar is formed. The leaves of plants, however, must be regarded as organs of assimilation rather than of respiration, in which crude sap is converted into cambium by the decomposition of carbonic acid, or the appropriation of its carbon and the liberation of oxygen. Nor is it unworthy of notice, that mushrooms, mosses, algæ, lichens, and other plants which have no leaves for

of external temperature for the manifestation of their powers. The consequence of which is, that they have no complex organs of assimilation and absorption, no nervous and muscular tissues, no sensation, perception or power of locomotion. But a still more remarkable difference between them is, that plants have the faculty of converting the binary constituents of inorganic matter, such as water, carbonic acid, and perhaps ammonia, into their own substance, by a peculiar species of action, intermediate between ordinary chemistry and that of animal bodies,—whereas the latter cannot be nourished except by plants that have been already organized, or by other animals that have been ultimately nourished by plants. It is therefore evident that, as animals have no means of assimilating inor ganic matter, they could not exist without plants.

On the other hand, it has been wisely ordained, that those substances, which are rejected by animals as excrementitious and injurious, are the appropriate food

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decomposing carbonic acid, have no visible organs of circulation, secretion or reproduction, and consist chiefly of a simple homogeneous cellular tissue. It may also be observed here, that the lowest species of animals, which have no specific organs of respiration, have neither heart, brain, nerves, muscles nor blood; and consist chiefly of a gelatinous mass, such as the medusa, polypus, echinus, sponge and other zoophytes, which are scarcely to be distinguished from plants. M. Becquerel observes, in a lecture delivered before the Academy of Sciences at Paris, on the 13th of July, 1840, that plants have a temperature of their own, though very different from that of the surrounding media,—but that *it is inappreciable during the night, on account of their sleep, and shows itself under the influence of light.* Query: might not the difference of temperature between day and night explain the phenomenon quite as well as the supposed influence of sleep?

of vegetables. And it would seem to be a law of nature, that plants not only supply animals with nourishment, but preserve the atmosphere in a state of purity, by absorbing the vast quantities of carbonic acid generated during the decomposition of organic matter, the respiration of animals and by ordinary combustion, including what is thrown into the atmosphere by volcanos and hot springs. For we learn from the recent work of Liebig, on the application of organic chemistry to agriculture, that except during the early growth of plants, they receive very little carbon from the soil, and actually derive nearly the whole of it from the atmosphere, which contains about one one-thousandth part of its weight of carbonic acid, 27 per cent. of which is pure carbon. He further maintains, that as a column of air, weighing 2216·66 pounds, Hessian measure, rests upon every square Hessian foot, the whole atmosphere must contain three thousand billion pounds of carbon in the gaseous state; that as a single man consumes 45 cubic feet of oxygen in twenty-four hours, or 16,425 cubic feet annually, one thousand millions of human beings would increase the amount of carbonic acid in the atmosphere 100 per cent. in one thousand years, by respiration alone, without taking into account the enormous quantities supplied by other sources.

For example, he estimates the yearly amount of oxygen consumed by ordinary combustion, in the town of Giessen, as eight times greater than what is required for the respiration of seven thousand human beings. And it is certain, that a much larger amount of carbonic acid is generated by the decomposition of vege-

table and animal matter, than by all the other operations of nature. We are therefore authorized to conclude, that if the atmosphere were not continually purified by the growth of plants, it would very soon become incapable of supporting life. For it was ascertained by Dr. Dalton, that the air of churches and other crowded assemblies contains about one per cent. of carbonic acid, which is extremely prejudicial to health. It was also ascertained by the experiments of Allen and Pepys, that when animals were made to inhale air which had been repeatedly inspired, they exhaled less carbonic acid than when breathing fresh air, in the ratio of 9·5 to 32 cubic inches per minute. But in the transcendently beautiful scheme of Providence, as displayed in every department of nature, partial evil only tends to the general preservation and welfare of the whole system. The demi-philosopher might pronounce carbonic acid a positive evil, because when inspired in any considerable quantity, even for a short time, it causes convulsions and death. But the Author of nature has ordained, that the formation of this same poisonous gas in the lungs should be essential to the conversion of chyle into blood, and to the evolution of that spiritual fire by which all animals are endowed with life, sensation, the power of motion, &c.; while it is equally essential to the growth of plants, in the leaves of which it is decomposed,* the carbon being

* In addition to the oxygen returned to the atmosphere by the leaves of plants, Liebig maintains, that in the formation of lignin, starch, sugar, acids, and especially oils or resins, water is decomposed, its hydrogen being assimilated and its oxygen returned to the air. (Vol. i. pp. 17–22.) Dr. Draper says that plants can ob-

retained, and the oxygen returned to the air in that state of purity required for the respiration of animals. In a recent paper read before the Academy of Sciences, by M. Leblanc, he states, that in the great lecture-room of the Sorbonne, (after being filled one hour and thirty minutes,) and in one of the Parisian churches, the amount of carbonic acid was about one per cent.; while in hospital wards it was from three to eight times more than in the open air. But in the closed green-houses of the Jardin des Plantes, the air was pure as out of doors.

> See all things with each other blending,
> Each to all its being lending,
> All on each in turn depending—
> While everywhere diffused is harmony unending.
> (FAUSTUS, by *Göethe.*)

PHILOSOPHY OF EXERCISE.

It was long ago observed by Hippocrates, that nothing is more essential to good health than a just proportion of aliment and exercise; and that as it is the

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tain carbon from the air only when the sun is shining on them, and that the decomposition of carbonic acid is effected by the yellow ray, in contradistinction from the blue extremity of the spectrum, in which the result is not produced. But MM. Mohl and Schleiden have shown, that the decomposition of carbonic acid by the leaves of plants takes place in the dark, though slowly, as might naturally be supposed from the fact that all the vital functions of plants are diminished at night, owing to a reduction of temperature. Nor will any of the rays of light produce the effect without a sufficient amount of caloric. MM. Cloes and Gratiolet have recently proved, that the decomposition of carbonic acid by aquatic plants exposed to light, does not take place below the temperature of 27° F., and that the process augments with the temperature up to 54° F.

tendency of exercise to diminish the substance of the body, it is the object of aliment to replace what has been lost. (*De Diœtâ*, lib. i. sec. 2; and lib. iii. sec. 8.) Yet, it must be admitted, that he never fully explained any one of the vital functions.

In regard to the influence of exercise on respiration, we are indebted to the celebrated Lavoisier for the first accurate experiments, which were performed on M. Seguin, a vigorous and healthy young man. When surrounded with air at the temperature of 59° F. and at rest, it was found that he consumed at the rate of 1344 cubic inches of oxygen per hour; but that when he performed the labour of lifting a weight of fifteen pounds to the height of 613 feet in fifteen minutes, he consumed at the rate of 3200 cubic inches of oxygen per hour. It was further ascertained, that after taking a hearty meal of animal and vegetable food, he consumed from 1800 to 1900 cubic inches of oxygen per hour when at rest, during the process of digestion, and 4600 cubic inches while lifting the above weight, *cœteris paribus*. (*Mém. de l'Acad. des Sciences*, 1789.)*

Thus it would appear, that respiration is augmented above 100 per cent. by exercise beyond what it is in

* Scharling also found, that during the month of June, a man weighing 131 pounds, and thirty-five years of age, exhaled when fasting 145 grains of carbon per hour, but 190 grains after breakfast and a walk, 165 grains after dinner, 160 grains after tea, and 100 grains while asleep. (*Simon's Chem. of Man*, p. 113.) In another series of experiments, a man thirty years of age was found to exhale 12·06 grammes of carbon per hour when remaining at rest, but when wielding violently a heavy iron rod, and perspiring freely, the same man exhaled 42·2 grammes of carbon per hour. (*Year-Book of Science and Art*, 1852, p. 223.)

a state of repose; and that it is increased about 40 per cent. after taking a hearty meal. The consequence of which is, that a corresponding amount of caloric is imparted to the blood, and the temperature of the whole body elevated, as shown by the increased action of the heart, the sensible glow of warmth that is experienced, and the flow of perspiration that follows.* Hence, also, it is, that men in health can endure a temperature of 32° during moderate exercise, with more comfort and safety, than one of 50° while in a state of rest; and that when supplied with an abundance of food, they can endure the most intense degrees of cold, so much better than during abstinence, as observed by Franklin, Ross and other travellers in the arctic regions.

We have also seen, that the vital activity of all the organs, and the rapidity with which their composition is renewed, are in proportion to the amount of caloric

* In accordance with the absurd theory of Bacon, Boyle, Borelli, Boerhaave, Haller and many others, that heat is the effect of motion, friction, &c., it was maintained by Cullen, that "animal heat is probably the effect of the motion of the blood, because in dying animals, the heat grows less as the motion of the blood grows less; and when at death it ceases altogether, the heat ceases also in a very short time." (*Institutions of Medicine.*) It is almost incredible, that this sentence should have been written after Cullen was made acquainted with the great discovery of Dr. Black. Nor is it less remarkable, that Dr. C. Holland should have maintained that exercise increases respiration and animal temperature, by causing a less amount of blood than usual to pass through the lungs in a given time. (*Laws of Organic and Animal Life.*) Dr. H. maintains, in various parts of this work, that the less the quantity of blood which passes through the lungs in any given time, the more perfectly is it organized and vitalized.

that passes through them in a given time, in combination with the arterial blood by which they are nourished. But as it is a law of nature that the *cause of force is always expended in producing motion, the vital heat of animals is wasted more rapidly during violent exercise, than it is obtained by respiration.* The truth of this proposition is proved by the well-known fact, that long-continued muscular exertion is followed by more or less exhaustion, and by diminished power of enduring cold. For, notwithstanding the elevation of temperature thus induced, the absolute amount of caloric in a state of combination with the organs is reduced below the usual standard; while it is equally obvious, that in proportion as respiration is increased during violent exercise, must it be diminished afterwards, for the plain reason, that a large amount of the carbon and hydrogen by which the vital combustion is supported, has been already given off in the lungs.*

As a further proof that the caloric obtained by respiration, and transferred to the different organs in combination with arterial blood, is forced out and expended during their action, it is stated by Dr. Granville, that during the violent contractions of the uterus which mark the progress of difficult parturition, its

* When respiration has been accelerated for several hours by exercise, it is afterwards proportionally diminished, if not supported by fresh aliment, for the same reason that a pound of fuel is sooner exhausted by a rapid combustion than when the process is moderate. This was experimentally proved by Dr. Prout, who found that, in his own person, the amount of carbonic acid exhaled was always much diminished by fatigue, abstinence from food and the depressing emotions or anxiety of mind. (*Annals of Philosophy*, vol. ii. pp. 328–43.)

temperature sometimes rises to 110°, and even 120°. Dr. Edwards also relates a case of tetanus, on the authority of Dr. Prevost, in which the temperature of the body rose 12·6° during the spasms. (*Infl. of Physical Agents*, p. 490.) But this is an exceedingly rare occurrence.

We further learn from some experiments of Becquerel and Breschet, that the temperature of the biceps muscle of the arm was elevated from 1·80° to 2·60°, by making it contract repeatedly for five minutes. These results were obtained by uniting two needles at their points, and thrusting them into the muscle when extended, while the other extremities of the needles were connected with the wires of a thermo-multiplier; when the rise of temperature was measured by the deflection of a magnetic needle connected with the multiplier. (*Cyclop. of Anat. and Physiology*, vol. ii.)

Thus we perceive, that after caloric has performed its vital office of causing a muscle to contract, it is given out in a free state, when it deflects the magnetic needle.*

* Dr. Edwards observes, that "the first source of the heat evolved during exercise, lies in the voluntary muscles." (*Cyclop. of Anat. and Physiology*, vol. ii. p. 615.) But we have seen that the "first source" of animal heat is the lungs, where it is obtained from the atmosphere, imparted to the blood and then to the different organs, where it is expended in maintaining their activity. And it might as well be said that caloric is generated *de novo* by hammering a metal, instead of being forced out from between its particles, as that it is generated by muscular contraction, secretion, nutrition or any other species of vital action. Moreover, as the power of an organ when once exhausted, cannot be again restored,

I have also proved, in the fourth book and fourth chapter of this work, that so soon as the caloric by which the particles of arterial blood are united with the different organs is expended, they successively fall from their places,* when they are taken up by the absorbents, conveyed into the general circulation, and thence through the lungs, where the greater part of

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without an additional supply of animal heat from the blood,—so has it been found, that when the ductility of iron has been diminished or destroyed by forcing out a portion of its latent caloric by hammering, it cannot be restored until resupplied with what it had lost, by exposing it to the fire. In the *Treatise on Diet*, which has been generally ascribed to Hippocrates, the author observes, that "during exercise a portion of our nourishment is consumed by the natural heat; that another portion is expired in the form of air (carbonic acid?); while a third portion passes off in the form of urine." He adds in the next section, "that a portion of the fluids is carried off by expiration; a portion by expectoration; while *another portion is employed in maintaining the heat of the soul;*" that exercise renders the head clear, the senses acute, and the bowels free, when in moderation; but that *when carried to excess it often brings on chills*, which, if not promptly removed by the warm bath, long-continued frictions, and a little weak wine, until the veins become full and turgid, are followed by troublesome fevers. (Lib. ii. sec. 131, 132, 149.) But if immoderate exercise often brings on the cold stage of fever, (which is certainly the case,) this important fact proves that our vital heat is rapidly expended by muscular and nervous exertion.

* The extent to which the vital cohesion of the solids is diminished by violent exercise, is strikingly illustrated by the fact, that the flesh of a stag hunted to death is far more tender than if bled to death, and undergoes putrefaction in a much shorter time, as stated by John Hunter. And it was observed by Autenreith, that a muscle taken from an animal before its irritability had ceased, putrefied much sooner if stimulated to frequent contractions, than if left at rest. (*Müller's Elements*, p. 52.)

their carbon and hydrogen is given off, in combination with oxygen. In the mean time, the compounds of nitrogen, oxygen, soda, lime, and other salts, together with the small remainder of carbon and hydrogen not employed in respiration, pass off chiefly through the kidneys in the form of urine, and partly through the bowels and skin. From which it follows, that *every muscular contraction, every thought, feeling or emotion of the brain, is attended with a loss of that vital heat by which all the organs are enabled to perform their respective functions, and of the substance by which they are nourished;* that the power of vision is diminished by exposure of the eyes to a dazzling light, for the same reason that the brain is exhausted by intense thinking, and the muscles by violent exercise. Hence it is, that a daily supply of food is required to restore the waste of the solids; and that the amount required to maintain the standard weight of the body is always in proportion to the degree of exertion. This was strikingly illustrated in the case of Captain Barclay, who, when performing his great feat of walking one thousand miles in one thousand successive hours, consumed daily, from five to six pounds of animal food, with a proportional quantity of bread, vegetables, wine, ale, porter and tea. (*Lond. Quarterly Rev.*, vol. lxv. p. 322.) It has also been ascertained, that without a large addition to the usual allowance of prisoners employed in the treadmills of England, they lose about one pound in weight every week, and become greatly emaciated in a few months; that they are extremely

liable to severe colds, rheumatism, bowel complaints, scurvy and other maladies arising from debility.*

It is because the substance and vital energy of the body are expended by exertion, that the growth of all young animals is retarded by premature labour. Blaine, the veterinarian, says that "horses early and hard-worked, never arrive at their full size." Hence also it is, that the mean duration of life among the working classes in England, does not equal that of the higher orders; although it must be admitted that imperfect nourishment, impure air and intemperance, augment the evil. The same observation applies to coach horses, which are worn out in a few years by active service. And it is said that in the hilly parts of Scotland, the shepherd's dog cannot labour above five or six years, but eight or nine years on the low lands.

The waste of the body is accelerated by intense cold, for the same reason that it is augmented by exercise; that is, because the animal heat by which the molecules of arterial blood are united with the solids is abstracted by the surrounding media more rapidly than it is obtained by respiration; so that notwithstanding the natives of the polar regions consume a larger amount of food than the inhabitants of warm and temperate climates, they are stinted in growth, and life is of short duration. The rapid expenditure of caloric by exercise and exposure to cold, creates the sensation of a vital want, or what the French

* At the treadmills, the number of feet in ascent per diem, varies from 44,000 to 50,000 in ten hours; or from nearly eight to nine and a half miles.

denominate *besoin de respirer*, which causes the individual to take more deep and frequent inspirations; while the consequent waste of the solids creates the sensation of hunger, which prompts him to take more or less food, according to the amount of waste.

In like manner, the expenditure of animal heat and of the solid tissues by exercise, faster than they are renewed by respiration and nutrition, diminishes the vital energy of the brain, nerves and voluntary muscles, and thus creates the necessity for repose or sleep, the object of which is to repair what has been lost. Nor is it unworthy of remark, that after exposure to intense cold for a few hours, or until the body is chilled and benumbed, there is generally a feeling of drowsiness and tendency to sleep, which are also induced by exhaustion from over-exertion. It is therefore evident, that *an expenditure of the vital heat and substance of the body, whether by exercise or exposure to cold, faster than they are renewed by respiration and nutrition, is the proximate cause of fatigue, hunger and sleep.*

When the lungs are large and sound, and men are supplied with an abundance of nourishing food, they can endure protracted exercise and intense cold without serious injury.* But when exhausted by loss of

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* Edward Johnson maintains, that "it is possible, by very rapid exertion, to fill almost every vein in the body with arterial blood." But, as if not aware, that although arterial blood is thus rapidly formed and united with the solids, it is still more rapidly expended by exertion, he recommends walking four or five miles every morning, the same distance before dinner, and the same again in the evening. (*Life, Health and Disease*, pp. 278–85.) This would, doubtless, be the way to obtain a full development of the lungs and muscular system; but it would certainly be at the expense of

blood, or when its vital properties are greatly impaired, as in phthisis, disease of the heart, the advanced stages of fever, scurvy and some other maladies, fainting, and sometimes sudden death, is often induced by comparatively slight exertion, obviously because the small amount of force thus expended is not renewed by the nutritive process. It is generally known that violent exercise diminishes and sometimes arrests the process of digestion, by diverting arterial blood from the stomach to the voluntary muscles; and that life is often destroyed suddenly by a large draught of cold water, which abstracts the small remainder of caloric from the capillaries of the stomach and paralyzes the action of the heart. For the same reason, digestion is always impaired when the stomach is weak, and often entirely arrested for some time, by drinking cold fluids, which are a very frequent exciting cause of flatulence, colic, cardialgia and spasms, which are more promptly relieved by hot drinks and the application of external warmth, than by any other means.

A correct knowledge of the manner in which animal heat is expended by exercise, will enable us to explain why it is that when greatly fatigued, health is often destroyed by immersion in the cold bath, which sud-

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the brain, which is generally small and feeble among pedestrians, wrestlers, boxers, country labourers, and all individuals who take much exercise, compared with what it is in men employed in intellectual pursuits, and who lead a less active life. The true method of securing the highest degree of physical, intellectual and moral excellence, is to exercise all the organs within the limits of pleasurable excitement, without producing fatigue, which is incipient disease, and should therefore be carefully avoided.

denly reduces the body below the natural standard, paralyzes the lungs, diminishes respiration, and thus lays the foundation of pneumonia, phthisis or some other fatal malady, if not prevented by immediate recourse to the warm bath or the application of dry heat, until the circulation is perfectly restored.* Nor is there a more frequent predisposing cause of fever, dysentery, cholera, diarrhœa† and congestion of the liver, than exposure to rain, fogs, damp night air or even a moderately cool draft of air, when fatigued by over-exertion, especially in hot climates, where the smaller amount of caloric obtained by respiration is much sooner expended by exercise than in the higher

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* I knew a case of incurable hemiplegia brought on a vigorous man in the prime of life, by walking ninety miles, (from London to Birmingham,) in three successive days. And it is well known to medical men, that when the muscles have been weakened by over-exertion, they are more liable to rheumatic inflammation than at other times; that when the loins have been overstrained, exposure to a slight cold will bring on lumbago. But it is consoling to know by experience, that in recent cases of rheumatism, the weakness of the capillaries may be very soon overcome by the repeated employment of hot applications, aided by gentle frictions.

† The last illness of President Polk was brought on by over-exertion in putting up his library, and in superintending other domestic affairs, after his return home from Washington. His fatigue was followed by slight fever, and the next day with diarrhœa, which continued for three days, when it was arrested by his physician, Dr. Hay. But his strength was so far exhausted, that the *vis medicatrix naturæ* was inadequate to her task, and he expired on the 17th of June, 1849, aged fifty-three years and seven months. His fatigue was augmented by conversations with Dr. Edgar and others, on the subject of his baptism, which was finally performed by his friend, the Rev. Mr. McFerren, a Methodist minister.

latitudes; so that a very slight exposure brings on a chill, and torpor of the internal organs.

The exhaustion of animal heat by violent exercise, has been long practically recognized by sportsmen, who are careful to cover the race-horse with a warm garment immediately after he reaches the goal, with a view to prevent his taking cold. Veterinarians are also aware, that horses are far more liable to tetanus from exposure to cold, when fatigued by violent exertion, than at any other time; and that what is called a *founder*, is generally brought on by drinking too much cold water, (which is also the cause of colic,) when they have been over-exercised.*

Many persons imagine,—and I am not sure that even medical men are wholly free from the same error, —that the danger from exposure to cold after fatigue, is owing to what they call an *over-heated* state of the body. But there is not the slightest danger of taking cold when the body is over-heated by the warm bath, as proved by the Russians, who have found that it enables them to endure cold for a much longer time than they otherwise could; and that after coming out

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* The danger of cold bathing when exhausted or much weakened by exercise, is strikingly illustrated by Quintus Curtius, who relates of Alexander the Great, that "after making a forced march to save the City of Tarsus from being burned by the Persians, he plunged into the cold waters of the River Cydmus. Having scarce entered the water his limbs began to grow cold with a sudden trembling; then paleness spread over him, and the vital heat almost left his whole body. His attendants took him, like a dying person, in their arms, and carried him, not rightly in his senses, into his tent." (QUINTUS CURTIUS, lib. iii. c. 5.)

of the vapour bath, the lower orders often roll themselves in the snow with impunity. The fact is, that whenever the circulation is languid, respiration is augmented by the warm bath, which increases the action of the heart, and causes a larger amount of blood to pass through the lungs in a given time, as explained in the preceding chapters of this work.

CHAPTER II.

ON ALIMENTS.

"In cold regions, more food is necessary to enable the animal to resist the rigours of climate, and a greater degree of stimulation is requisite for the evolution of heat, than would be endured in the equatorial latitudes; while the inhabitants of warm climates are instinctively led to the choice of vegetable food, because it stimulates in a smaller degree, and is attended with a smaller evolution of animal heat."—SIR CH. MORGAN.

THE object of food in the animal economy is to supply materials for supporting that incessant process of combustion in the lungs, by which the temperature and vitality of the body are maintained, and its composition renewed.* Nor can there be a rational doubt,

* I met in the Philadelphia *Ledger* of June, 1849, the following estimate of the amount in value expended annually for heat in the United States:—

Fuel in families	$66,000,000
Warmth of clothing	66,000,000
" of houses	132,000,000
Fuel in factories, shops, &c	36,000,000
Total	$300,000,000

But the vital heat of all animals is obtained by the combustion of their food, for which a still larger sum is expended. The annual production of grain alone amounted to above $500,000,000 in 1846, without regard to hay and pasturage. The fact is, that if we except mere luxuries, physical and mental, nearly all the labours

that a complete knowledge of all the changes which it undergoes while passing through the system, would explain nearly everything hitherto mysterious in the operations of life. For it involves the whole theory of respiration, sanguification, secretion and nutrition, by which the perpetual waste of all the organs is repaired.

From the earliest periods of history down to the present time, it has been a question among philoscphers, whether animal or vegetable food is better calculated to promote health, strength, beauty, long life and the highest development of the intellectual and moral faculties. But we have already seen that the aliment of nations, like their clothing, habitations, manners, customs, social economy, complexion and general organization, have been determined chiefly by climate and geographical position, to which the institutions of lawgivers and founders of religious creeds have been, to a greater or less extent, accommodated. And it will be found, that in every part of the world, nature has supplied in greatest abundance those descriptions of food best suited to the well-being of its inhabitants.

For example, the tropical regions abound with rice, yams, dates, sugar-cane and an exhaustless variety of fruits; but owing to a deficiency of the more nutritive

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of life are expended, one way or another, in obtaining and preservng the caloric which supports our being, the annual cost of which cannot be less than $800,000,000. Yet how small in amount is the caloric thus obtained, compared with what we receive from the sun, without which there could be no vegetable growth, therefore no fuel, no food, in short, no existence!

species of grass and grain, they are less adapted to the multiplication of domestic animals than temperate climates, which abound with wheat, rye, barley, oats, potatoes, rich grasses, the olive and vine, with a great variety of fruits and vegetables; while the polar regions afford neither grass, grain nor fruits, and no vegetable aliment excepting a few stunted mosses, but abound with reindeer, bears, seals, the walrus and other cetacea. It is therefore evident, that nature has provided a large predominance of vegetable food in the torrid zone, of animal food in the frigid zone, and a due mixture of both in the intermediate latitudes; consequently, that if the Budhists and Brahmans of India, the Essenes of Palestine and the Pythagoreans of southern Europe, had resided in Scythia, Siberia or British America, they could not have required total abstinence from animal food.

It is also a beautiful provision of nature, that most of the animals in the polar regions afford a much larger proportion of oil or fat, than those of the middle latitudes; and those of hot climates still less, *cæteris paribus*. For it is said that the Greenland whale has been known to afford thirty tons of oil, or 50 per cent. of its whole weight, and the smaller cetacea in like proportions;* whereas the average ratio of fat in mo-

* By means of an immense blanket of fat, from eight to fifteen inches thick, the whale is enabled to preserve his own temperature at from 100° to 104° amidst the polar icebergs. And when employed as food, it enables the Esquimaux to maintain their temperature at the natural standard, while surrounded with air at from 50° to 70° below 0° F., with no other habitations than snow huts, and no fires except miserable oil lamps.

derately well-fed beef, mutton and pork, in England, is about 25 per cent. of their weight.* In a full-grown ox, the whole amount of lean meat is estimated at four hundred pounds. But in some rare cases, the animal has been so far loaded with fat as to weigh two thousand pounds; the proportion of fat being as four to one of muscular flesh, which contains about 75 per cent. of water, and therefore only 25 per cent. of solid matter. It must, however, be observed, that poultry, veal, lamb, venison, hares, rabbits and nearly all wild animals, contain very little fat, more especially in hot climates.

But according to Boussingault, the proportion of solid matter in wheat when deprived of water, is 95 per cent. And if we estimate the ratio of pure flour at 90 per cent. it follows that 2·20 pounds of wheat will afford two pounds of starch and gluten; whereas it requires eight pounds of lean fresh meat to afford two pounds of nutritive matter when deprived of water. The potato also contains from 24 to 33 per cent. of starch and gluten, according to the analyses

* According to Mr. Brande, the proportions of solid matter in the muscular and albuminous portions of fresh meat, are 29 per cent. in mutton, 27 in chicken, 26 in beef, 25 in veal, 24 in pork, 21 in cod, 21 in sole, and in haddock 18; while it is generally estimated that the average is 25 per cent. In eggs, there is about 30 per cent. of albumen and oil, according to Dr. Christison; while in milk of the cow, goat and ewe, the proportion of caseine, sugar and oil, is from 12 to 14 per cent., according to O. Henry and Chevallier. So that a cow giving sixteen quarts of milk per diem, would afford 3·84 pounds of solid aliment, allowing the milk to contain 12 per cent., and 4·48 pounds if it contained 14 per cent.; two-thirds of which would be oil and sugar.

of M. Payen; so that if we estimate the average at only 25 per cent. eight pounds must afford the same quantity as two pounds of flour, and the same proportion of solid matter as eight pounds of fresh lean meat.

Let us now examine the chemical composition of the more important aliments. In the following table they are reduced to three classes. The first embraces the principal constituents of grain and other vegetables; the second, the fibrin, albumen and caseine, of both animal and vegetable food; while the third division exhibits the composition of alcohol, essence of pepper and the most important descriptions of oil or fat.

Substances analyzed.	Carbon.	Hydrogen.	Oxygen.	Nitrogen.	By whom analyzed.
Starch	44·250	6·674	49·076	....	Berzelius.
Cane sugar	42·225	6·600	51·175	....	Berzelius.
Sugar of milk	40·	6·73	53·27	....	
Grape sugar	36·71	6·78	56·51	....	
Gum	41·906	6·788	51·306	....	Berzelius.
Acetic acid	40·	6·67	53·33	....	
Citric acid	41·369	3·800	54·831	....	Berzelius.
Tartaric acid	35·980	3·807	60·213	....	Berzelius.
Malic acid	41·38	3·45	55·17	....	
Animal fibrin	53·671	6·878	23·688	15·763	Scherer.
" albumen	53·850	6·983	23·494	15·673	Scherer.
" caseine	54·825	7·153	22·394	15·628	Scherer.
Vegetable fibrin	54·617	7·491	22·083	15·809	Jones.
" albumen	55·01	7·23	21·84	15·92	Jones.
" caseine	54·138	7·156	23·034	15·672	Scherer.
Gelatinous tissues	50·048	6·477	25·125	18·350	Mulder.
Calf's-foot tendon	49·563	7·148	24·819	18·470	Scherer.
Caffeine	49·77	5·33	16·12	28·78	Liebig.
Theine	50·101	5·214	15·676	29·009	Jobst.
Mustard	49·53	5·02	11·74	13·45	
Alcohol	51·980	13·700	34·320	....	Saussure.
Piperine	80·95	8·13	10·92	....	Göbel.

Substances analyzed.	Carbon.	Hydrogen.	Oxygen.	Nitrogen.	By whom analyzed.
Linseed oil............	76·014	11·351	12·635	....	Saussure.
Olive oil..............	77·213	13·360	9 427	....	Gay-Lussac.
Spermaceti...........	78·000	11·800	10·200	....	Ure.
Tallow	78·996	11·700	9·304	....	Ure.
Lard.....................	81·660	12·862	5·478	....	Chevreul.

From the above table we perceive that the proportions of carbon and hydrogen in the vegetable acids and grape sugar, vary from 40 to 46 per cent.; in cane sugar, gum and sugar of milk, from 46 to 48, while in the starch of grain and other vegetables they amount to 50 per cent.; but that the fibrin, albumen and caseine, of both animal and vegetable matter, contain about 60 per cent. and the various species of oil or fat about 90 per cent. of carbon and hydrogen, or 30 per cent. more than lean meat, and from 40 to 50 per cent. more than pure farinaceous food, sugar, gum and the sub-acid fruits.

It is therefore evident, that the latter are especially adapted to tropical and warm climates, where a smaller amount of animal heat is required than in the higher latitudes, where the articles contained in the second division of the table are more appropriate; and that in the polar regions, where animal heat is rapidly abstracted by the surrounding air during winter, oily food is peculiarly adapted for supplying its loss, by supporting a rapid combustion in the lungs. Hence it is that the Esquimaux, Samoieds and Tungouses prefer blubber and train oil to any other description of aliment, but have no relish for vegetable food; that they often consume ten pounds or more of animal and oily food per diem, according to the reports of nume-

rous travellers; who also inform us, that while wintering in those desolate regions, European sailors prefer the fattest meat they can obtain. And hence it is, that throughout the northern and middle latitudes of Europe, more animal food is consumed than in southern France, Italy, Spain, Portugal and Greece; while it is well known that in southern Asia, tropical Africa, the South Sea Islands and nearly all tropical or warm climates, the inhabitants live chiefly on rice, bread, fruits and vegetables, with a little milk, butter and fat.

It also follows from the foregoing data, that a man who daily consumes twenty-four ounces of rice, flour, oatmeal, barley, maize or any other species of farinaceous aliment, gum, sugar, &c., cannot afford above ten or twelve ounces of carbon and hydrogen for the support of respiration; whereas the same weight of fresh lean meat deprived of water would afford about 14·40 ounces; and the various species of oil above twenty ounces. But as we have seen that fresh lean meat does not contain above 25 per cent. of solid matter, twenty-four ounces would afford only six ounces of nutritive matter and 3·60 ounces of carbon and hydrogen. In accordance with these facts, we are informed by Mr. Ross Cox, an agent of the American Northwestern Fur Company, that the men employed in active service, and without any other aliment, consume eight pounds of fresh meat per diem; and that their allowance is ten pounds if it contain any bone. I am also credibly informed that, under the same circumstances, the hunters belonging to the Hudson's Bay Company, consume about the same quantity of meat daily,—which would afford two pounds of nutritive

matter and 1·20 pounds of carbon and hydrogen. But it is well known that a labouring man in Europe is well supported on two pounds of flour, rice, oatmeal or barley, any of which contain about one pound of carbon and hydrogen, or a little more if we allow for the gluten, which, as will be seen presently, varies from 8 to 13 per cent.* And it has been ascertained by Government Commissioners, that when the peasantry of Ireland have no other food than potatoes, they consume about eight pounds per diem,—which contain the same amount of farinaceous matter as two pounds of flour. It is also well known that a full-sized horse or ox, weighing seven hundred pounds, may be well supported on ten pounds of grain per diem; and that a lion weighing three hundred and fifty pounds requires ten pounds of fresh meat daily; so that if he weighed seven hundred pounds he would require twenty pounds. In accordance with this fact, I have ascertained that a cat of average size requires six ounces of meat per diem, and, if allowed, would consume much more. It is therefore evident, that the various species of grain afford a much larger amount of nourishment than the same weight of fresh lean meat.

We are informed by Major Tulloch, that the weekly rations of the British troops are seven pounds of fresh and salted meat, seven pounds of flour, two and a half

* It is equally certain that men who live a sedentary life may be well nourished on a much smaller amount of the same species of aliment. Cornaro subsisted on twelve ounces of farinaceous food, with fourteen ounces of weak wine per diem, during the greater part of his long life, in the mild climate of Italy, while the Hindoos and Chinese live on from sixteen to twenty-four ounces of rice daily.

pints of peas, ten ounces of rice, nine ounces of sugar, five ounces of cocoa and two pints of spirits. If, then, seven pounds of meat contain 25 per cent. of fat, it will make twenty-eight ounces, which contain 90 per cent. of carbon and hydrogen, or twenty-five and one-fifth ounces. And if we suppose that seven pounds of lean meat contain 25 per cent. of solid matter when deprived of water, there will remain twenty-eight ounces of muscular and albuminous matter, which contain 60 per cent. of carbon and hydrogen or 16·8 ounces, making in all 3·5 pounds of solid fat and lean meat, which contain two pounds ten ounces of carbon and hydrogen for the support of respiration. But if we add together the flour, peas, rice, sugar and cocoa, they will make eleven pounds of vegetable aliment, which contains 50 per cent. of carbon and hydrogen or 5·5 pounds; making in all fourteen pounds eight ounces of nourishment per week, independent of spirits, and eight pounds two ounces of carbon and hydrogen.

From which it follows, that a British soldier consumes daily about two pounds one ounce of solid animal and vegetable food, which contains one pound two ounces of carbon and hydrogen; consequently that in the course of a year his allowance of aliment amounts to seven hundred and fifty-four pounds, of which four hundred and twenty-two pounds consist of carbon and hydrogen, leaving three hundred and thirty-four pounds of oxygen, nitrogen, sulphur, phosphorus and salts.

In accordance with the above facts, we are informed by Liebig, that the German soldiers belonging to a

company of the body-guard of the Grand Duke of Hesse-Darmstadt, consume daily as much animal and vegetable food as afforded 13·9 ounces of carbon, independently of hydrogen, which must have amounted to about two ounces, making in all 15·9 ounces.* He has also proved, that so long as the body does not increase in weight, all the carbon and hydrogen taken into the stomach, not discharged as urine and fæces, unite with atmospheric oxygen to form carbonic acid and water, which, like the solid excrements, are nothing else than the incombustible or imperfectly burned parts of the food; and that the compounds in which nitrogen predominates pass off through the kidneys in the form of uric acid, urea, ammonia and the different salts; that the superabundant carbon and hydrogen not eliminated from the lungs, are converted into fat and deposited in the cellular tissue, where it remains until required by abstinence† or increased exercise, when it is taken up by the absorbents, conveyed into the general circulation and thence into the lungs, from which it is given off as carbonic acid and water.

* But this far exceeds the daily consumption of the civil population in any part of Europe. Liebig states, that in a family of his acquaintance, consisting of five adults and four children of different ages, the average quantity of carbon in their daily food was 9·5 ounces.

† In support of this view, he adduces the loss of fat and general emaciation that takes place in many animals during hybernation, when they remain in a state of partial lethargy for months, without any food. He also relates the case of an individual who was unable to swallow, *whose body was reduced one hundred pounds in weight during a month.* (*Animal Chemistry*, vol. ii. p. 25.)

He then shows, that as caloric enough is evolved during the combustion of one ounce of carbon to raise one hundred and five ounces of water 135°,—the 13·9 ounces of carbon contained in the daily food of a German soldier would, on uniting with atmospheric oxygen, afford heat enough by respiration to raise one ounce of water 197,032°, and three hundred and seventy pounds of water from 32° to 98·3°; that if the quantity of heat carried off with three pounds of water in the form of vapour, from the lungs and skin, be 51,097°, there will remain 145,935° for maintaining the temperature of the body, independent of what is obtained from the combustion of hydrogen. He therefore concludes that *animal heat is derived wholly from the action of oxygen on the combustible elements of food, or of the structures formed from it,* as was long ago maintained by Black, Crawford, Lavoisier, Dalton and many other distinguished chemists.

But although Liebig has triumphantly refuted the absurd hypotheses that animal heat is generated by nervous influence, secretion, nutrition, muscular motion, &c., candour obliges me to say, that he has overlooked some of the most important facts connected with the theory of respiration. For example, he maintains, in various parts of his late work, that atmospheric oxygen is conveyed from the lungs to every part of the body, where it unites with carbon and hydrogen to form carbonic acid and water; that "the globules of the blood, which can be shown to take no share in the nutritive process, serve to transport the oxygen, which they give up in their passage through the capillary vessels." (*Op. cit.* p. 60.)

But that atmospheric oxygen combines with carbon and hydrogen in the lungs, is evident from the fact, already stated, that in mammalia the temperature of blood is from 1° to 3° higher in the lungs, left ventricle of the heart and carotid arteries than in the right ventricle of the heart, vena cava, or jugular veins, as noticed by Black, Haller, Plenck and Menzies, but fully demonstrated by the numerous careful experiments of Dr. John Davy, which I have verified by many observations on recently killed sheep and oxen. I have also proved that, during the passage of arterial blood through the systemic capillaries, *the caloric obtained by respiration in the lungs is employed in combining a portion of its organic particles with the solids, in maintaining the various secretions and the vital activity of all the functions.* (See book iv., chapters ii. and iv.

I have further shown, from the experiments of Michaelis and Mulder, that venous contains more carbon and hydrogen than arterial blood; consequently, that they must unite with atmospheric oxygen while passing through the lungs, where caloric is obtained, with an excess of oxygen and nitrogen.

But in the total absence of these experiments, which Liebig has overlooked, *the combination of oxygen with carbon and hydrogen in the lungs is sufficiently demonstrated by the facts, that the temperature of the blood is elevated while passing through the lungs, and diminished while passing through the systemic capillaries, where it ought to be raised, if oxygen there combined with carbon and hydrogen.* Yet, as if wholly unaware of these facts, Liebig asserts, that "arterial and venous blood

have the same temperature." (*Page* 272.) It is therefore evident, that his whole theory of respiration and animal heat is fundamentally erroneous; while in some respects it is even more defective than that of Black, Lavoisier, Crawford and Dalton, who maintained rightly, that animal heat is evolved in the lungs, and given up by the blood to the solids in the systemic capillaries; but without explaining what office it performs in any of the vital functions. And, so far is it from being true, as maintained by Liebig, that "the globules of the blood take no share in the nutritive process," that they are far more abundant in arterial than in venous blood, as proved by the numerous experiments of Prevost and Dumas, Denis, Le Canu, Mayer, Autenrieth, Berthold, Letellier and others. It is therefore manifest, that while passing through the systemic capillaries, a portion of them is dissolved, expended in nourishing the solids and in maintaining the various secretions.

It is one of the most extraordinary facts in the history of modern science, that Liebig should have neglected to ascertain the difference between the temperature and chemical composition of arterial and venous blood; for this very difference constitutes the key to a right knowledge of animal physiology.* Had this

* The consequence of this neglect has been, that his theory of fever is more defective, if possible, than any before offered. For example, he says, that "if in consequence of a diseased transformation of living tissues, a greater amount of force is generated than is required for the production of the normal motions, it is seen in an acceleration of all or some of the involuntary motions, as well as in a higher temperature of the diseased part. This condition is

celebrated chemist given us more analyses, and fewer hypotheses, he would have avoided many grave and fundamental errors, which now essentially detract from the value of his work. But he seems not to know what kind of experiments are most requisite to the elucidation of animal physiology. His explanation of the decomposition or waste of the solids, affords a curious example of the manner in which the greatest strength must fail when embarked in a wrong path at the outset.

In accordance with the foregoing hypothesis, that oxygen is conveyed by the blood globules to all parts of the body, he maintains that "atmospheric oxygen is the proper, active, external cause of the waste of matter in the animal body; that it acts like a force which tends to destroy the manifestation of the vital force at every moment;" that "*by the absorption of oxygen into the substance of living tissues, these lose their condition of life, and are separated as lifeless, unorganized compounds;*" that "the cause of waste of matter is the chemical action of oxygen;" that "the globules

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called fever." Again he observes, that "as the motions of the circulating system and of the intestines increase, the power of producing mechanical effects in the limbs must diminish in the same proportion as in wasting fevers." (*Pages* 229, 256.) But I have shown that the preternatural temperature of fever and inflammation is always owing to a derangement of the blood, which is no longer in a state to unite with the solids as during health; so that the caloric which is usually transferred to the solids, is given out in the free state; that the increased action of the heart is owing to the preternatural temperature of the blood; and *that the vital energy of the whole body is diminished,* owing to a failure of the nutritive process.

of arterial blood, in their passage through the capillaries, yield oxygen to certain constituents of the body;"* that "a small portion of this oxygen serves to produce the change of matter, determines the separation of living parts, and their conversion into lifeless compounds; while the greater part is employed in converting into oxidized products the newly formed substances which no longer form part of living tissues;" that "in their return toward the heart, the globules which have lost their oxygen, combine with carbonic acid, producing venous blood;" that "the globules of arterial blood contain a compound of iron saturated with oxygen, which, in the living blood, loses its oxygen during its passage through the capillaries;" that after losing a part of their oxygen, they become venous, and combine with carbonic acid, which is given off in the lungs, when they again absorb oxygen, which is conveyed to all parts of the body; that "*waste of matter occurs in consequence of the absorption of oxygen into the substance of living parts;*" that in cases of starva-

* He maintains, that as all the tissues of the body contain, for the same amount of carbon, more oxygen than the constituents of blood—during their formation, oxygen, either from the atmosphere or from the aliment, is added to the elements of *proteine*, which he regards as the basis of albumen, and the starting-point of all the tissues; that the gelatinous tissues contain an excess of nitrogen and hydrogen, in the proportions to form ammonia; that vegetable albumen, fibrin and caseine are the only parts of plants capable of being converted into actual nourishment; and that they are identical in composition with the nitrogenized constituents of the animal tissues—not only in containing the same proportions of carbon, hydrogen, nitrogen and oxygen, but of sulphur, phosphorus and phosphate of lime.

tion, and in all chronic diseases, death is produced by the chemical action of oxygen, by which every part of the body, except the bones, is consumed by a slow combustion; and that the true cause of death in these cases is the respiratory process. (*Pages* 28, 223, 238, 243, 259, 271.)

Now it is worthy of special notice, that in no part of his work, has Liebig explained what causes the constituents of arterial blood to combine with and nourish the solids; the consequence of which has been, as might naturally be supposed, that all his speculations in regard to the cause of waste have been founded on hypothetical and erroneous assumptions.* But we have seen that atmospheric oxygen unites with carbon and hydrogen in the lungs, where caloric is evolved; that the caloric is thence conveyed into the systemic capillaries, where it causes a portion of the fibrin, albu-

* He is equally in error with regard to the cause of the circulation; for he represents the heart as a forcing-pump, which sends blood into all parts of the body; and also a suction-pump, by means of which all fluids, of whatever kind, as soon as they enter the absorbent vessels which communicate with the veins, are drawn toward the heart,—the expansion of which produces a vacuum, into which the blood is forced by the external pressure of the atmosphere. (*Op. cit.* p. 58.) For the rationale of the circulation, the reader is referred to the fourth book of this work, chapter iii. Nor is it true, as Liebig maintains, that *the capacity of the chest, the volume of oxygen consumed, and the standard temperature of animals are the same, whether at the poles or the equator,—nor that pulmonary diseases arise from excess of oxygen, and hepatic diseases from excess of carbon.* (*Pages* 20, 24.) Never did any work on physiology contain a greater number of pernicious errors—most of which are already exploded; and others are destined, ere long, to share the same fate. (*Note to the scond edition.*)

men and red globules of arterial blood to combine with the solids, and to form the various secretions,—by which the temperature and vital activity of all the organs are maintained at the expense of the arterial blood, the temperature and vital properties of which are diminished, when it assumes the venous state; that so soon as the caloric by which the particles of arterial blood are combined with the tissues is expended by their action, the vital attraction of the solids gradually ceases, when they are more or less rapidly dissolved, taken up by the absorbents, conveyed into the general mass of venous blood, and thence into the lungs, where the whole is reconverted into arterial blood, until nearly all the carbon and hydrogen are given off as carbonic acid and water; while the remaining compounds of oxygen, nitrogen, sulphur, phosphorus and salts pass off through the various emunctories as dead matter.

It is therefore evident, that the "waste of matter" is not owing to "the absorption of oxygen into the substance of living parts," but to an *expenditure* of the vital heat obtained in the lungs, and transferred to the different organs while passing through the systemic capillaries; that in cases of starvation, and in chronic diseases, death is not produced by the chemical action of oxygen, and a slow combustion in every part of the body, but that the proximate cause of death is a failure of the nutritive process and a general dissolution of the solids, which are reduced to the state of inorganic compounds, by giving off carbon and hydrogen in the lungs; while those in which nitrogen predominates, are carried off through the kidneys and

bowels as lifeless matter. Thus it is, that when deprived of food, respiration is supported, and the body nourished, at the expense of the blood* and of its own ruins; that the substance of the brain, nerves, muscles, &c. is rapidly dissolved, conveyed into the general circulation, and thence into the lungs, where they are consumed by a slow combustion, attended with dizziness, mental debility, stupor, delirium, weakness of the limbs, hollowness of the features and rapid emaciation, which are the leading symptoms of starvation, as described by Captain Bligh.

The observations of Liebig on the cause of animal motion, would have been noticed when treating on that subject, had not the fourth and fifth books of this work gone to the press before I examined his second volume. He there states that "everything in the animal organism to which the name of motion can be applied, proceeds from the nervous system;" that "no change of condition can occur in the body without the nerves, which are essential to all vital motions;" that "under their influence the viscera produce those compounds, which, while they protect the organism from the action of oxygen of the atmosphere, give rise to animal heat;" that "by means of nerves, all parts of

* Among all the wonders of nature, there is nothing more miraculous than the self-repairing powers of the living body. Nor is it very easy to explain why it should wear out in threescore years and ten. Compared with this *chef-d'œuvre* of creation, the grandest inventions of human genius are but rude and imperfect imitations. Had the steam engine the power of conveying its worn-out particles to the furnace, and of converting them into new materials for repairing the loss arising from motion and friction, it would slightly approximate the perfection of the living frame.

the body, all the limbs, receive the moving force which is indispensable to their functions, to change of place, to the production of mechanical effects;" that "where nerves are not found, motion does not exist;" that "the excess of force generated in one place, is conducted to other parts by the nerves;" and that "from the unequal degree of conducting power in the nerves, we must deduce those conditions which are termed paralysis, syncope and spasm." (Vol. ii. pp. 3, 30, 219, 230.)

Yet in opposition to all these assertions, (which are refuted by the well-known existence of motion in plants, and in many of the lower animals that have no nerves,) he maintains in the same volume, that "*the only known ultimate cause of vital force, either in animals or plants, is a chemical process;*" that "the ultimate cause of all the forces in the animal body is a change of material particles by the conversion of food into oxidized products;" that "the process of chymification is independent of the vital force, and is purely a chemical action."* (*Pages* 30, 32, 34, 108.)

* It is very true, that food may be converted into chyme by the chemical action of gastric juice alone, even out of the stomach, if kept at the temperature of the body, as demonstrated by the experiments of Dr. Beaumont and others. But does Liebig really believe, that the secretion of gastric juice is not as much a vital process as nutrition, muscular motion or any other function? And does he mean seriously that bile is not essential to chylification, because of the small proportion of nitrogen it contains; or that it serves merely for the support of respiration? The most probable opinion is, that bile unites with chyme to form chyle, and that the excess of carbon and hydrogen not required to form blood, is given off in combination with oxygen. For it is stated by Müller, on the

But in direct contradiction of all these statements, he observes in another place, that "*the cause of the phenomena of living bodies is not a chemical force;* it is a force which has certain properties in common with all causes of motion and of change in form and structure in material substances. It is a peculiar force, because it exhibits manifestations which are found in no other known force." (Vol. ii. p. 232.) And he tells us in the first volume, that "the vital principle is a power distinct from all the other powers in nature." When he says of the soul, that "it is no object of physical investigation," it would seem that he understands as little of what the ancients meant by the *soul* or *vital principle,* as he does of the *essence* or origin of anything in nature, whether spiritual or corporeal.

What is still more remarkable, Liebig has offered no explanation of the office or agency of heat in digestion, sanguification, secretion, nutrition, sensation and muscular motion; but at the commencement of his work, represents it as an immaterial agent, like light, electricity and magnetism. I am therefore less sur-

authority of Shultz, that in oxen which had not recently taken food, there was found from twelve to sixteen ounces of bile in the gall-bladder, but only from two to four ounces after digestion. Hence it is, that when the process of digestion is arrested, as during fever, or only diminished, as in hot climates, there is a superabundance of bile, which is discharged by vomiting, or passes downward, causing bilious stools. Hence also the reason why Hippocrates, Galen and nearly all the ancients, regarded bile as the *cause* of fevers; an opinion which has prevailed to a greater or less extent among mankind ever since, and is still most potently believed by the vulgar.

prised than I should otherwise have been, that at one time he represents all vital action as proceeding from the nervous system; at another time, from chemical action;* again, from a peculiar force, distinct from all the other powers of nature; and fourthly, that he should observe in another place, "we resemble the ignorant man, to whom the motion of an iron piston rod in a cylinder, in which the eye can detect no visible agent, and its connection with the turning of thousands of wheels at a distance from the piston rod, appear incomprehensible."

Liebig further maintains, that the proximate constituents of the blood and organized tissues of animals are all originally produced in the organism of plants;

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* But as he offers no explanation of the primary or ultimate cause of chemical action, it is evident that he has no fulcrum on which to place his lever. For example, Liebig maintains that "all bodies in the act of combination or decomposition, have the property of inducing those processes;" that "a molecule set in motion by any power, can impart its own motion to another molecule with which it may be in contact;" that "the most general condition for the production of *eremacausis* (a slow combustion) in organic matter, is contact with a body in that state; for the communication of combustion is in reality the effect of contact,"—of which he offers many illustrations that admit of a different and far more satisfactory explanation. (See vol. i. pp. 221, 237, 267, 70, 74, 373.) For I have proved that without caloric there could be no motion among the particles of common matter; that it causes oxygen to unite with all the other elements of ponderable matter or with any of them separately, without any previous contact with a body in the state of combustion. It is therefore perfectly natural, as caloric is evolved during every process of combustion, and as there could be no combination or decomposition without it, that the contact of a burning body should increase the chemical action of other bodies.

that "all such parts of vegetables as can afford nutriment to animals, contain constituents rich in nitrogen;" that "animals require for their support and nutrition less of these parts of plants in proportion as they abound with nitrogenized constituents;" that "no nitrogen is absorbed from the atmosphere in the vital process;" yet that "the chief ingredients of the blood in all animals, contain nearly 17 per cent., and no part of an organ less than 17 per cent. of nitrogen;" that "in the absence of starch, sugar, fat, gum, &c. the oxygen of the atmosphere combines with the tissues;" that "the metamorphosis in existing tissues, and consequently their restoration or reproduction, must go on far less rapidly in graminivora than in carnivora;" that starch, sugar, gum, fat, pectin, bassorine, wine, beer, spirits and all substances not containing nitrogen, are incapable of being transformed into blood, and serve merely to support respiration; but that as flesh, vegetable fibrin, albumen and caseine, contain the proximate constituents of blood and the animal tissues ready formed, they alone are capable of supporting the nutrition and growth of animals. He therefore reduces all aliments to two classes, one of which he calls *elements of respiration, and the other, elements of nutrition;* maintaining, that if animals were not supplied with the former, their organism would be destroyed by the action of atmospheric oxygen; and that if not supplied with nitrogenized matter, they would perish from starvation. (Vol. ii. pp. 43, 45, 75, 76, 96.)

In support of the assertion, that all the nitrogen contained in the blood and organized tissues of ani-

mals is obtained with their food and none from the atmosphere by respiration, Liebig has offered no experiments of his own; and what is rather surprising, has not taken the slightest notice of the numerous and accurate experiments of many distinguished chemists, whose results are in direct opposition to his theory. Passing over those of Priestley, it was found by the varied and often repeated experiments of Spallanzani, on birds, mammalia, reptiles and insects, that in nearly all cases, respiration was attended with a notable disappearance of nitrogen. The same results were obtained by the still more careful experiments of Humboldt and Provençal, who found that during the respiration of fishes, the mean proportion of nitrogen that disappeared was as 57·6 to 145·4 of oxygen. It was also ascertained by numerous experiments of Sir Humphrey Davy on himself, that about 18 per cent. of nitrogen was permanently absorbed during respiration; after which similar results were obtained by Henderson and Pfaff.

These general results have been confirmed by the experiments of Macaire and Marcet, Michaelis, Magnus, Dr. Clanny, Mulder and others, who have found that *there is more nitrogen in arterial than in venous blood;* which could not be the case if it were not absorbed from the atmosphere. Yet we are told, that in a majority of the experiments performed by Dulong, Despretz and Nysten, more nitrogen was exhaled during the respiration of warm-blooded animals than was absorbed. What is still more incredible, (because contradicted by innumerable experiments of many of the most distinguished chemists in Europe,) it is

stated by Liebig on the authority of Despretz, that more nitrogen is exhaled from the lungs of herbivora than of carnivora. But if the German professor had examined these results with the same attention which he bestowed on Dulong and Despretz's theory of animal heat, he would have found them equally fallacious.*

Some highly important experiments performed by Dr. W. F. Edwards, enable us in some measure to comprehend the contradictory results of different chemists, and even those of the same individuals at different times or under different circumstances. For example, he found that more nitrogen was exhaled by new-born Guinea pigs and puppies, living on milk, (which contains much more nitrogen than vegetable food,) than was absorbed; that the same was true of adult sparrows, during spring, summer and autumn, until the twenty-second of October; after which time there was a striking disappearance of nitrogen; and that when yellow-hammers were kept fifteen minutes in a vessel containing 94·6 cubic inches of air, during the latter part of autumn, winter and the beginning

* It is curious enough, that since the first edition of this work was published, Liebig has shown it to be utterly impossible that animals should exhale such a vast amount of nitrogen as the experiments of Dulong and Despretz would lead us to believe. For example, a dog weighing eleven hundred and fifty grammes, exhaled at the rate of 6·75 litres, or 7·46 grammes of nitrogen gas in twenty-four hours, according to the experiments of Dulong. But Liebig has shown, that if all of this nitrogen proceeded from the animal, its whole body would be exhaled in about seven days. (*Lancet*, vol. i. p. 201, 1845.)

of spring, the amount of nitrogen was diminished in almost every instance.

Now although Dr. Edwards does not notice the fact, it is well known that sparrows, yellow-hammers and most of the smaller birds, live to a considerable extent during the warmer months, on worms and insects, that afford, like milk and other animal matter, a much larger amount of nitrogen than grain, which forms the principal nourishment of birds after the middle of October, when their summer food is removed by the cold season. We are therefore authorized to conclude, that when animals live on vegetable food, which contains less nitrogen than is requisite to form blood, the deficiency is obtained from the atmosphere by respiration,* as shown by the experiments of Priestley, Spallanzani, Humboldt and Provençal, Davy, Henderson and Pfaff; but that when they live on food which contains more nitrogen than is required to form blood, the excess is exhaled from the lungs, or discharged from the kidneys, as shown by some experiments of Jurine, Berthollet, Dulong, Despretz and Nysten. Besides, Dr. Edwards found that nitrogen was sometimes absorbed and at other times exhaled, during the respiration of man.†

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* It is during the passage of chyle, venous blood and the waste materials of the solids through the lungs, that the whole is converted into arterial blood, by giving off carbon and hydrogen; and by absorbing nitrogen from the atmosphere, whenever that element is deficient in the food. It is also in the lungs where blood is formed, and where, after it has performed its vital office of nourishing the tissues, the whole is converted into oxidized products and other inorganic compounds.

† Were it not for the large amount of nitrogen discharged in

But if we examine the chemical composition of animal and vegetable foods, it will be found that their nutritive value is far from being in proportion to the amount of nitrogen they contain. For example, the first two columns of the following table exhibit the proportions of solid matter and of nitrogen, in different species of vegetable food, when dried at temperatures from 212° to 230°, according to the experiments of Boussingault himself, recorded in the *Annales de Chimie et de Physique*, tome lxiii. To these I have added two other columns, representing the quantities of vegetable aliment required to afford as much nitrogen as one pound of lean meat deprived of water; and the proportions of nitrogenized matter in one hundred parts of vegetable food. The third column was obtained by dividing the quantity of nitrogen contained in the dry fibrin, albumen and caseine of the animal tissues, (estimated by Liebig at 17 per cent.) by the numbers in the second column. The fourth column was then obtained by finding how often the numbers in the third column go in one hundred parts:—

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the urine of carnivorous animals, there would be more of it exhaled from the lungs than actually takes place. From the recent experiments of Prof. Lehman he found, that when he lived twelve days on animal diet alone, (consisting of thirty-two eggs daily the last six days,) his urine contained 821·37 grains of urea, and five-sixths of all the nitrogen ingested. But that when he lived twelve days on a vegetable diet, the amount of urea was reduced to 347·10 grains. He also found, that when living on animal food alone, 22·64 grains of uric acid were discharged through the kidneys every twenty-four hours; but only 11·24 grains when using food that contained no nitrogen.

	Solid matter.	Nitrogen.	Equivalents to 1 lb. of animal matter.	Quantity of nitrogenized matter.
Wheat	95·	2·30	7·40	13·51*
Oats	87·6	2·20	7·42	13·
Barley	86·8	2·02	8·42	11·86
Maize	82·	2·00	8·5	11·76
Rice	—	1·39	12·23	8·17
Rye	90·	1·70	10·	10·
Potatoes	27·	1·80	9·44	10·58
Peas	83·3	4·20	4·04	24·75
Horse-beans	92·1	5·50	3·09	32·
White haricots	95·	4·30	3·95	25·
Lentils	91·	4·40	3·86	25·
Carrots	12·4	2·40	7·08	14·12
Turnips	8·8	2·20	7·72	13·
White cabbage	7·7	3·70	4·59	22·
Ordinary hay	88·8	1·50	11·33	8·82

From the foregoing table, we perceive, that if only the nitrogenized portions of food were capable of being transformed into blood and the various tissues, one pound of lean meat deprived of water, (which is a binary compound, and supports neither respiration nor nutrition,) ought to afford as much nourishment as 7·40 pounds of wheat, 8·42 pounds of barley, ten pounds of rye, 11·18 pounds of maize, or 12·23 pounds

* According to the experiments of Vauquelin, the proportion of gluten in hard Odessa wheat is 14·55 per cent., and 10·20 per cent. in that of the Paris bakers. But it would seem to vary greatly according to the nature of the soil; for Boussingault relates some experiments of Hermstedt, which show that wheat grown on a soil manured with ox blood, or human urine and excrements, afforded from 33 to 35 per cent. of rough gluten; while that produced on a soil manured by cow dung, or pigeons' dung, afforded about 12 per cent. When manured with vegetable mould, the proportion was 9·6 per cent., and 9·2 per cent. on the same soil not manured. Similar experiments should be often repeated, for the purpose of arriving at greater certainty.

of rice,*—which is positively contradicted by all experience,—for every one knows, that a horse or ox weighing seven hundred pounds may be well supported on ten pounds of pure grain per day. But I am informed by the celebrated Van Amburgh, that a lion of the largest size requires every twenty-four hours from ten to twelve pounds of clear flesh, during six days in the week; and from sixteen to eighteen pounds when mixed with bone, as in a neck-piece of fresh beef; that his large tiger consumes nearly the same quantity, and the lioness about ten pounds; that the spotted jaguar, or Brazilian tiger, which weighs from one hundred and ninety to two hundred pounds, requires daily from six to seven pounds of clear flesh, and the leopard five pounds. If, then, the Brazilian tiger weigh two hundred pounds, and require seven pounds of fresh meat a day, he would require twenty-

* It also follows, that one pound of peas and beans ought to be equal, in nutritive value, to two pounds of wheat or barley, and three pounds of rice. But even Liebig admits, that peas and beans are of inferior value as articles of nourishment, because, as he thinks, they are deficient in phosphate of lime and magnesia. It is well known, however, to farmers, that they are excellent food for horses and other domestic animals, especially when boiled or ground into meal. And I am disposed to believe that they contain a larger proportion of nutritive matter than was estimated by Sir Humphrey Davy, who represents it as 57 per cent. In wheat he found it 95 per cent., in barley 92 per cent., in rye 72·2. Again, if the quantity of nitrogen in dry hay be 1·50 per cent. and a measure of its nutritive value, eleven and one-third pounds ought to afford as much nourishment as eight and a half pounds of maize—which is absurd, and contrary to all experience. Even Boussingault admits, that twenty-seven pounds of wheat are equal to one hundredweight of ordinary hay.

four and a half pounds if as large as a full-grown horse or ox. And if we estimate the proportion of water in twenty-four and a half pounds of lean meat at 75 per cent., there will remain 6·12 pounds of nutritive matter, which would be consumed daily by a carnivorous animal weighing seven hundred pounds. But the quantity of nitrogenized matter in ten pounds of oats, barley or maize, varies from 1·17 to 1·30 pounds. From which it is obvious, that, according to Liebig's theory, a carnivorous animal weighing seven hundred pounds would take in with his food above five times more nitrogen than a horse living daily on ten pounds of grain. It also follows, that as there is only 1·80 per cent. of nitrogen in dried potatoes, thirty-eight pounds, in the fresh state, would be required to afford as much nitrogen as four pounds of lean fresh meat, allowing both to contain 75 per cent. of water. And as it requires one hundred pounds of fresh turnips to afford 8·8 pounds of dry solid matter, which contains 2·2 per cent. of nitrogen, nearly eighty-four pounds would be required to afford as much nitrogenized matter as one pound of dry fibrin, albumen or caseine.*

* If, then, it be a fact, that lean fresh meat contains 4·25 per cent. of nitrogen, while the constituents of grain, potatoes and turnips contain only from 1·39 to 2·30 per cent. of that element, how is it possible that herbivorous animals can exhale more nitrogen than such as are carnivorous? For we have seen that the latter consume a larger amount of food in a given time, in proportion to their weight; and that the same amount of nitrogen enters into the composition of both classes. It therefore follows, that all granivorous animals, and a large majority of the human race, who live

Again, so far is it from being true, that man and other animals require less food in proportion as it abounds with nitrogen, that a much larger amount of lean fresh meat is required than of wheat, barley or any other farinaceous aliments, as we have already seen with regard to carnivora and herbivora. We have also seen that the hunters of America consume daily about eight pounds of fresh meat, when they have no other food; while it is certain that the labouring classes of Europe are equally well supported on twenty-four ounces of flour made into bread, with eight ounces of fat bacon; that the Irish peasantry, who live on eight pounds of potatoes a day, are superior in size, strength and activity to those of England, where the proportion of beef and mutton consumed is three times greater than in France, four times greater than in Prussia, five times greater than in Austria, and six times greater than in Italy or Spain. The peasantry of Scotland, who live chiefly on oatmeal and potatoes, with milk,* and just meat enough to flavour

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chiefly on vegetable aliments, must derive a portion of their nitrogen by respiration, or by swallowing it with their food in the form of air. It cannot, then, be admitted, that their food contains all the nitrogen found in their excretions. According to Le Canu, a full-grown man rejects every twenty-four hours, in his urine alone, about half an ounce of nitrogen; this amount of nitrogen is contained in about three ounces of muscular flesh, which must, therefore, be removed every day by the waste of the body. To restore this waste, there must be eaten thirty ounces of flour, or forty-five of bread, if all the nitrogen expelled be derived from our food.

* I am credibly informed, that the children of the wealthier classes in Scotland are fed chiefly on oatmeal porridge and milk, until the age of puberty. But the solid portions of cow's milk, when deprived of water, do not contain above four per cent. of

their vegetable broth, are superior in health, strength and longevity to the North American Indians, or to any other race of men in the world, who subsist chiefly on animal food. It is also well known, that in almost every country in Europe, above half the population is supported chiefly on bread, milk, potatoes and other vegetables, with a little butter and fat, which contain no nitrogen; that the agricultural labourers of England, Holland, Germany, Poland, Russia, Sweden, Denmark, Canada and New England prefer the fattest pork they can obtain; because they say it goes farther, and supports their strength better, than lean meat. Nor is it improbable, that about four-fifths of the human race derive nearly all their nourishment from the vegetable kingdom: for it is certain, that throughout southern Asia, a large portion of Africa, the South Sea Islands and tropical America, nearly all the inhabitants live chiefly on rice, bread, yams, sugar, oil, dates, lemons and other fruits.*

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nitrogen, and human milk not much over half that proportion; so that it approximates the composition of farinaceous food, the starch of the latter being replaced by oil and sugar. But according to the new theory, skimmed milk ought to afford more nourishment than new milk, because the ratio of nitrogen is larger in a given weight of the former, for the cream is supposed not to be convertible into blood. And if one pound of lean meat, deprived of water, contain 17 per cent. of nitrogen, it ought to afford as much nourishment as four and a half pounds of the solid parts of milk, which contain only four per cent. of that element. Such are the conclusions to which we are inevitably brought by adopting the premises of Liebig.

* Macaulay says, that one hundred and sixty-five years ago, (1685,) one-half the common people of England ate animal food twice a week; whereas the other half ate it not at all. (*History of England*, vol. i. p. 391.)

But if men and other animals were nourished only by those parts of food which contain nitrogen, a man living on twenty-four ounces of rice per day would consume only about two ounces two drachms of aliment capable of being transformed into blood and the various tissues of the body—all the rest being employed in supporting respiration. And if a labouring man consume twenty-four ounces of flour in the form of bread, with eight ounces of fat meat, he would take only three ounces of actual nourishment, or about six times less than is contained in the daily food of a horse living on ten pounds of pure grain, which affords about twenty ounces of nitrogenized matter. But we have seen that a Brazilian tiger, weighing two hundred pounds, consumes six pounds of fresh beef, which contains twenty-four ounces of nitrogenized matter; so that if his weight were one hundred and fifty pounds, (the average of man,) he would take daily eighteen ounces of matter capable of being transformed into blood, and six times more than the labouring man who lives on twenty-four ounces of flour, with eight ounces of fat meat, and nearly as much as a horse weighing seven hundred pounds.

Is it then true, that sanguification, secretion, nutrition and growth are six times more rapid in carnivora than in herbivora? That the process of waste and renovation is far less rapid in the latter than in the former, as maintained by Liebig? So far is this from being the case, that the calf, lamb, kid and pig grow much faster than any of the carnivorous quadrupeds.*

* I have been informed by respectable butchers, that a calf eighteen weeks old, fed on milk and various species of farinaceous

Nor is it possible that the quantity of gluten in the food of herbivora and granivora can account for their rapid increase of weight.

The horse, ox, deer, sheep, goat, hare and rabbit have a higher mean temperature, with proportionally greater power of enduring cold and prolonged muscular exertion, than the lion, tiger, leopard, hyena, cat, or any species of carnivorous mammalia, if we except the dog, wolf and fox, whose blood is not richer in organic particles than that of the more active herbivora. And it has been observed, that the greyhound, when fed on hard biscuit, with milk and fat, is not less swift as a runner than when supplied with lean meat. There is also reason to believe, that during recovery from long illness, the weight of a

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aliment, has been known to weigh four hundred pounds; a lamb fifteen weeks old, sixty-five pounds; and a pig six months old, three hundred pounds. It is also well known that the hare and rabbit grow much faster than the cat, or any other carnivorous animal of the same size; and that the deer grows more rapidly than the dog, wolf or fox. The same general observation applies to birds. It is said by poulterers, that the domestic pigeon is nearly as large when only four weeks old as the parent bird, which consumes one ounce two drachms of barley per day. But this would afford only one drachm eleven grains of nitrogenized matter, which is manifestly insufficient to renew the composition and supply the rapid waste of the pigeon. The common fowl, when well fed, is usually considered as ready for market at the age of fourteen weeks; while it is certain that the turkey, ostrich and other granivorous or frugivorous birds grow faster than the eagle, vulture and other birds of prey. Yet we are gravely assured by Liebig, that the processes of renovation and waste are far less rapid in herbivora than in carnivora, and that the amount of nitrogenized constituents in the urine of animals is a measure of their nutrition and waste.

man, nourished chiefly on farinaceous and saccharine food, increases at the rate of about two pounds per day, and often greatly beyond that amount. And as we have seen that men require two or three times more lean meat for their support than of purely farinaceous and oily aliments, we are authorized to conclude, that starch, fat, gum and sugar not only support respiration, but that during this process, they are transformed into blood (by absorbing nitrogen from the air) capable of nourishing the tissues, like gluten and the nitrogenized portions of animal food.*

The opinion that substances not containing nitrogen are incapable of supporting animal life, has been

* Dr. Paris thinks that an ounce of fat contains nutriment equal to four ounces of lean meat. (*On Diet*, p. 72.) Nor can there be a rational doubt that honey, sugar, sago, tapioca and arrow-root, which contain little or no nitrogen, are highly nutritious. I have also been frequently told that the blacks of the West Indies and Brazil are never so hearty and well-looking as when they live freely on juice of the sugar-cane, with molasses. And we are informed by Sharon Turner, on the authority of Mr. Easton, that Rebecca Joseph, of Malpas, near Newport, in Monmouthshire, lived to the age of one hundred years, and her chief sustenance, for the last two years of her life, was brown sugar and water. (*Sacred History of the World*, vol. iii. p. 322.) It is therefore impossible to admit the assertion of Liebig, that starch, sugar, gum and oil are incapable of being transformed into blood by the chemistry of animal life. For it is manifestly not true, as he maintains, that the quantity of nitrogenized matter in the food of herbivora is amply sufficient for the growth and development of their tissues, and for the supply of waste. If this were the case, a cow fed on forty-two pounds of turnips would consume only two ounces of nitrogenized matter; whereas the milk of a cow giving sixteen quarts would contain above twenty ounces of caseine, which contains about 16 per cent. of nitrogen, or 3·20 ounces.

erroneously inferred from some experiments of Magendie, who found that when dogs were fed on sugar, butter, olive oil or gum, separately, with only water, they died in from thirty-one to thirty-four days. But he also found afterwards, that when rabbits and Guinea pigs were fed on wheat, barley, oats, carrots or cabbage, separately, with water alone, they died with all the symptoms of starvation in fifteen days, but suffered no ill effects when fed on the same articles simultaneously, or in succession. (*Physiology*, translated by Milligan, vol. ii. page 486, second edition.) It has also been clearly established, by a Report of the Gelatine Committee, (in the *Comptes Rendus des Séances de l'Académie des Sciences*, vol. v., Août. 1841,) that *fibrin*, *albumen* and *gelatine*, when taken alone and separately, will not support the life of dogs, although carnivorous animals,—but that an exclusive diet of muscular flesh, raw bones or gluten is capable of complete and prolonged nutrition. (*Pereira's Lect. on Foods; Pharm. Journal*, October, 1842.) Hence the vast importance to health of a mixed and varied diet, as indicated by the appetite, and the diversity of aliments supplied by nature.

There is reason to believe that the best possible nourishment for man is a mixture of animal and vegetable food in such proportions as to produce a composition resembling milk, which Dr. Prout very justly regards as the model of what our aliments should be in after life. He observes, that nearly all our artificial combinations of food are nothing more nor less than disguised imitations of the prototype milk; and that the more nearly they resemble this model, the more nearly

do they approach perfection. For example, by adding to flour fat, sugar and eggs, as in making pastry, we have a composition very nearly analogous to that of milk, which was evidently intended by nature for the nourishment of animals during a considerable period of their existence. Now it will be seen from the following analyses of O. Henry and Chevallier, that the average proportion of caseine in milk of the cow, ass, goat and ewe is as one to 2·23 parts of oil and sugar; while in that of woman, the difference is as one to 5·76:—

	Cow.	Ass.	Goat.	Ewe.	Woman.
Caseine	4·48	1·82	4·02	4·50	1·52
Butter	3·13	0·11	3·32	4·20	3·55
Sugar	4·77	6 08	5·28	5·00	6·50
Salts	·60	·34	·58	·68	·45
Total	12·98	8·35	13·20	14·38	12·02

Liebig maintains, that the proportion of caseine in the milk of woman is increased by her living on animal food; while the proportion of oil is increased by a farinaceous diet. (Vol. ii. p. 83.) But we perceive from the above table, that the ratio of caseine is 2·6 times greater in the milk of herbivorous animals than in that of woman, who lives partly on animal food. It also follows, according to Liebig's theory, that nearly six times more aliment is required to support the respiration of an infant, than is employed in its nutrition, and 2·23 times more in the calf, colt, kid and lamb. But so far is this from being the case, that the temperature of the calf, kid and lamb is several degrees higher than that of the infant; while experience demonstrates that human milk is not less nutritious than that of other animals. The inference

is therefore clear, that the sugar and butter of milk, like the starch of grain and other vegetables, serve not merely to support respiration, but are also convertible into blood and the various tissues,—consequently, that there is no foundation in nature for the division of food into "*elements of respiration and elements of nutrition.*"

The obvious tendency of Liebig's theory is to augment the consumption of animal food among mankind. But it is worthy of special notice, that *no highly civilized nation has ever yet been strictly carnivorous;* that the teeth, jaws, stomach, bowels and whole organization of man, resemble those of the monkey tribe much more nearly than those of carnivora; consequently, that man is specially adapted by nature to a vegetable diet, which, if sufficiently varied, is equally palatable, and far more conducive to health, strength, beauty, sweetness of body, intelligence, morality and urbanity of manners, than a diet of animal food alone; if not preferable to a mixture of both.*

In support of this view, it may be observed, that

* A writer in the *London Examiner*, of October, 1852, maintains that the Englishman is lumpish, heavy, harsh and phlegmatic, because of the immense quantities of half-cooked beef and mutton he devours; whereas the Frenchman is gay and sprightly, like his diet and beverage; that the English are strong drinkers, because they are gross feeders, whose digestion requires the aid of stimulants; while their Gallic neighbours, who use a lighter diet, seldom employ alcohol or even the lightest wines to excess; in fine, that the art of selecting and preparing food marks the progress of civilization, and is next in importance to the art of medicine. The truth is, that the *materia alimentaria* are of infinitely greater importance to man than the *Materia Medica.*

in all the attributes of a beautiful and vigorous organization, mildness of disposition, docility and usefulness, herbivorous animals are far superior to the carnivora, nearly all of which are characterized by ferocity, a fetid odour of the skin and breath, with a rank, disagreeable taste of the flesh, which was doubtless the reason they were forbidden as food by the laws of Moses.* I therefore agree with Pythagoras, Dr. Lambe and Mr. Shelley, that much of the savage cruelty which has characterized many barbarous tribes of mankind, may be in part ascribed to their exclusive use of animal food; although it must be admitted that some of the tribes inhabiting central Africa and the South Sea Islands, who life on fruits and vegetables, have been equally ferocious and cruel.

The superiority of vegetable over animal food is still more striking in an economical point of view. For example, if we estimate the average produce of wheat at twenty bushels, or 1250 pounds per acre; a square mile (640 acres) would yield 800,000 pounds, which would support a population of fourteen hundred and sixty-two individuals, allowing each to consume twenty-four ounces per diem throughout the year. And it is well known that an acre of ground will produce from 40 to 50 per cent. more barley, maize, oats, beans or peas, than of wheat. But if the products of an acre of ground be required to give 200 pounds of meat on an

* But when fed on a vegetable diet, the flesh of the dog and other carnivora is no less palatable than that of lamb and venison. The delicious flavour of the canvass-back duck is owing to its feeding on wild celery; and that of the green turtle has been attributed to its living on sea-moss.

average, a square mile would give 128,000 pounds; so that if it contain 25 per cent. of fat and 25 per cent. of lean meat, deprived of water, there would remain 64,000 pounds of nutritive matter, which would support one hundred and seventeen inhabitants, allowing twenty-four ounces for each. From which it follows, that land sown in wheat would support above twelve and a half times the number of inhabitants that it could if devoted to the rearing of cattle and sheep.*

But at present the number of horses in Great Britain is 2,166,000, and of cattle 13,000,000; so that if each of these animals consume as much food as five men, that of the whole would maintain a population of 75,830,000. If to this we add 56,000,000 sheep, and 25,000,000 pigs, their food would support a population of fifty millions of human beings, independent of what is employed in feeding poultry, deer, dogs and cats. And if an acre of ground can produce 22,000 pounds of potatoes, which are equal to 5500 pounds of wheat, a square mile would support four thousand eight hundred and twenty-one human beings. Nor is it improbable that the time may come, when animal food and woollen clothing may be exchanged for a vegetable diet (with perhaps milk, butter, eggs and fish,) and cotton clothing; when the work of animals will be performed chiefly by steam power; when the

* Sharon Turner says, that there are 58,000,000 acres of cultivable land in the Kingdom of Great Britain, every one of which would support a family on vegetable diet; whereas it requires three acres to support one family on flesh and vegetables; so that the United Kingdom would support 300,000,000 on vegetables, but only 100,000,000 on both. (*Sacred Hist of the Earth*, vol. iii.)

population of England shall be augmented from two hundred and eighty to one thousand on the square mile; and by a judicious variation of their vegetable diet, live far better than at present.* The following table, compiled by a recent author of great merit, who has chosen to remain anonymous, exhibits an estimate of the relative quantities of food that an acre of ground will produce in temperate climates:—

	Pounds.		Pounds.
Potatoes	22,000	Plums and Cherries	2,000
Mangold Wurtzel	22,000	Oats and Barley	1,840
Parsnips	11,000	Wheat	1,250
Cabbages	10,000	Mutton	224
Turnips	8,240	Beef	186
Apples	7,000	Milk	2,900
Pears	5,000	Butter	300
Onions	2,800	Cheese	200
Beans and Peas	2,000		

With regard to the quantity of aliment required to maintain health and strength, much depends on climate, season, age, sex, temperament and mode of life. To persons in robust health, and whose appetites have not been rendered dainty by silly tampering in early life, scarcely anything in the rich banquet of nature comes amiss; whereas, the feeble and phlegmatic re-

* In the northeastern provinces of China, where very few animals are reared for food, and still fewer for labour, the population varies from five hundred to nearly eight hundred on the square mile, without the advantage of machinery and other means of augmenting the comforts of life. It is therefore evident, that with the vast resources of Britain, and the adoption of a diet consisting chiefly of vegetables, she is capable of supporting in comfort more than 100,000,000 inhabitants, and that in such a state of things there would be no necessity for migration to other countries.

quire moderation and the choice of a light but nutritious diet. Perhaps there is no better guide than the instinctive appetite implanted by nature, which if not perverted by artificial and vicious customs, always prefers what is salutary, but revolts from the use of drugs and poisons. Let every one then partake in moderation of what he likes best, and cure repletion by abstinence or exercise, rather than resort to emetics and purgatives.

When more food is taken than is required to repair the waste of the solids, there is a superabundance of imperfectly formed blood, that abounds with oily matter, which if not carried off by suitable exercise, deranges the nutritive process, causing a feverish state of the body, indigestion, headache, low spirits, hysterics, gout, &c. For example, it is well known to the feeders of poultry, that after being crammed for ten days or two weeks, until loaded with fat, they become feverish and drooping. It is therefore obvious, that a large accumulation of fat is incompatible with a healthy condition of the blood, and should be prevented either by abstinence or by exercise, which, according to Lucian, performs the same office which winnowing does for corn, by blowing away the chaff and other impurities, while the pure grain is left behind.

Nearly all descriptions of food are more digestible and nutritious when cooked, than in the raw state, if we except the softer species of ripe fruits, (which are already more or less cooked by the heat of the sun,) and oysters, the albumen of which is coagulated like the white of eggs, by a high temperature. For the

same reason, warm meals are more easily digested by weak stomachs than cold. And we are told by the Chevalier Edelcrantz of Sweden, that the process is accelerated by warm clothing, but retarded by whatever reduces the temperature of the body below the natural standard. It is generally understood that the cold bath, even in summer, is injurious, if employed soon after eating.

In regard to the modus operandi of ardent spirits, wine, malt liquors and other stimulants, on the animal economy, very little has been ascertained with certainty. It is generally understood, that their activity is in proportion to the amount of alcohol they contain, which varies from 50 to 54 per cent. in spirits, from 10 to 26 in wines, and from 4 to 8 per cent. in porter and ale. But that caloric is the active principle in alcohol would appear from the fact, that when swallowed pure, or even diluted with nearly one half water, as in brandy, gin and whiskey, it produces a burning sensation in the throat and stomach, like so much liquid fire. And it is generally known, that the sudden mixture of alcohol with water is attended with a considerable elevation of temperature. The same heating influence is produced in the body by ether, ammonia and other stimulants.

Liebig maintains that the carbon and hydrogen of spirits, wine and malt liquors unite with atmospheric oxygen within the body and assist in the generation of animal heat, because, as he says, the expired air, perspiration and urine, do not contain any trace of alcohol after it has been used. This is doubtless the case when they are taken in small quantities, espe-

cially in combination with food. But when taken alone or in large quantities, they may be always perceived in the breath. They have also been detected in the blood, the ventricles of the brain and in the excretions, according to Magendie.

When taken in moderation, there is reason to believe that drinks containing alcohol augment the process of respiration, the action of the heart, and the circulation of blood through the lungs; thus producing a pleasurable glow of warmth throughout the body, a temporary flow of animal spirits and an accelerated activity of all the functions. In accordance with this view, we are informed by Dr. Paris, that Mr. Spalding consumed the oxygen of the air in his diving-bell much sooner when he drank spirituous liquors and employed a diet of animal food, than when he drank only water and lived on vegetables. On the other hand, it was found by the experiments of Dr. Fyfe and Dr. Prout, that the amount of carbonic acid generated in a given time by respiration, was always materially diminished by the use of spirits, wine and malt liquors, especially when taken on an empty stomach. (*An. of Philos.*, vol. ii. p. 328; vol. iv. p. 334.)

Nor can there be a doubt, that when taken in large quantities they are absorbed into the blood and conveyed to the brain, where by their narcotic influence they diminish its voluntary command over the function of respiration, as shown by the coldness of the extremities, languor of the circulation, giddiness, stupor, insensibility, loss of appetite, nausea, tremors and general prostration of strength, that characterize intoxication, which literally means the action of a poi-

son. It is therefore not surprising that their habitual use induces delirium, paralysis, apoplexy, epilepsy, madness and a frightful train of physical maladies, especially in hot climates. For it is certain, that they may be consumed in much larger quantities in cold than in warm and tropical countries, without causing intoxication or disease. And this proves that they afford a certain amount of caloric either by uniting with the fluids of the body or by increasing respiration, in the same way that animal food and fat produce this effect. Hence it is, that when the energies of life are exhausted, as in the latter stages of typhus, cholera, tetanus and other low forms of disease, they are often revived by the judicious employment of brandy, ether, wine, &c.

Yet there cannot be a rational doubt, that the abuse of these articles has caused a greater amount of physical and moral suffering than war, famine, pestilence or any other single calamity. If, by virtue of a strong constitution, a few drunkards have arrived at old age, millions are destroyed in the prime of life by intemperance. It was the opinion of Dr. Forry, that nine-tenths of the mortality in the United States army, at the salubrious posts of the north, was owing to the excessive use of ardent spirits. That intoxicating liquors are not sanctioned by nature would appear from the fact that they are generally disagreeable to the unvitiated taste of the lower animals and of young children; while it is notorious that their constant use diminishes the appetite of adults for wholesome food. The sooner we begin to assist nature by stimulants, the sooner she leaves us a prey to artificial

excitement, which is seldom beneficial except when the powers of life are reduced below par. If the £65,000,000 annually expended for spirits, wine and malt liquors in Great Britain, were rightly employed in the promotion of a sound physical and moral education of the lower classes, pauperism would soon disappear; while vast multitudes would be rescued from crime, madness and premature death.*

RECAPITULATION.

The cardinal facts embraced in this chapter may be reduced to the following general propositions:—

1. That each zone affords in the greatest abundance those descriptions of aliment best suited to maintain the well-being of its inhabitants.

2. That excessively cold climates abound with animals which contain a large amount of oil and fat, that are rich in carbon and hydrogen, which afford an abundant supply of animal heat where it is most required.

3. That the middle latitudes abound with grass, grain and domestic animals, which are less numerous and contain a much smaller proportion of fat in hot

* It is estimated that the annual cost of intoxicating drinks in France is $234,000,000, while it is about $100,000,000 in the United States, where the average consumption of proof spirits by each individual has been estimated at four and three-quarter gallons. In Sweden it is said to be seven gallons, in France nine gallons and in Great Britain eleven and a half gallons. The latter country pays annually for ardent spirits £30,000,000; for wines, £10,000,000; and £25,000,000 for 387,552,672 gallons of malt liquors.

climates, where there is an exhaustless profusion of saccharine fruits, gum and farinaceous aliments, that afford less carbon and hydrogen, therefore less caloric by respiration, than animal food.

4. That the various species of grain afford a much larger amount of actual nourishment than an equal weight of animal food, if we except cheese, butter, fat and lean meat deprived of water.

5. That during the process of respiration, starch, sugar, gum and fat are converted into blood, by absorbing nitrogen from the air and by giving off carbon and hydrogen; consequently, that the elements of respiration, when combined in due proportion, are employed in nourishing the solids, like the fibrin, albumen and caseine, of both animal and vegetable food.

6. That as the chemical composition of all animals is the same, herbivora must derive a portion of their nitrogen from the atmosphere, because their food does not contain enough of that element to maintain their nutrition and growth, which are even more rapid than in carnivora.

7. That the living body is a self-repairing machine, which has the power of transforming both ternary and quaternary compounds into its own tissues; and when wholly deprived of food, is capable of living for many days on its own ruins, which are repeatedly renovated in the lungs, where they are also gradually converted into carbonic acid, water and other inorganic compounds.

8. That the rapid increase in the weight of the body after long abstinence or illness, the speedy healing of

broken bones, the filling up of ulcers, and the rapid growth of herbivorous animals, all tend to prove that the nitrogenized portions alone of vegetable food are insufficient to account for the renovation of their composition and the supply of waste.

9. That a suitable variety of vegetable aliments is better adapted to the organization, health, strength, intelligence and moral excellence of the human race, than a diet of animal food alone.

10. That although spirits, wine and malt liquors,* when taken in moderation, elevate the temperature of the body, augment the circulation, produce a temporary flow of spirits, remove the sensation of hunger, fatigue and other disagreeable feelings; they impair the vital properties of the blood and diminish its coagulating power, when used to excess; derange the nutritive process, cause a dropsical or phlegmatic condition of the solids and gradually destroy the *vis medicatrix naturæ*, as shown by the slowness with which wounds and ulcers heal in intemperate drinkers.

* It is important that every one should know there is about three times more solid and nutritive matter in a pint of milk than in the same measure of porter, and twenty times more in a pound of good bread. Yet thirty-five million bushels of barley are wasted annually in England in making malt liquors, (which vitiate the breath and gradually destroy health,) or enough to nourish three and a half millions of human beings. Nor is there a more palpable error than the general opinion that malt liquors are essential to support the strength of a labouring man. But it is in vain to reason with men whose appetites and reasoning faculties have been perverted by artificial customs.

CHAPTER III.

SLEEP.

—"That knits up the ravelled sleave of care,
The *birth* of each day's life, sore labour's bath,
Balm of hurt minds, great nature's second course,
Chief nourisher in life's feast."—SHAKSPEARE.

It has been said that "sleep is the great miracle and mystery of life." The remark is true so far as this, that a complete theory of sleep necessarily involves that of life itself. And so it is of all the functions, whether healthy or morbid. I have already shown that the power of the stomach to digest, of the muscles to contract, of the brain to think and of the nerves to feel, is directly in proportion to the rapidity with which their composition is renewed, *cœteris paribus;* but that the animal heat obtained by respiration, and the organic particles of arterial blood by which the solids are nourished, are still more rapidly expended by the action of the brain and voluntary muscles, than they are renewed; in short, that the cause of force is always expended in producing motion or action; that the object of aliment is to supply materials for supporting respiration and for repairing the waste of the solids, induced by exercise; after which it is carried out of the system by the different emunctories, in the form of carbonic acid, sweat, urine, &c.

I shall now proceed to show, that *the proximate cause of sleep is an expenditure of the substance and vital energy of the brain, nerves and voluntary muscles beyond what they receive when awake; and that the specific office of sleep is the restoration of what has been wasted by exercise.**

That the necessity for sleep arises from an exhaustion of sensorial and muscular power, would appear from the fact, that it is induced by intense bodily pain, laborious exercise of the brain and voluntary muscles; when not carried so far as to interrupt the nutritive process. So pressing is the demand for it in cases of painful and difficult parturition, that women often fall into a slumber between the paroxysms of violent uterine contraction. They also require more sleep during gestation than at other times, owing to the expenditure of blood and vitality in support of the fœtus. In accordance with these facts, sleep is more profound and long continued, after the body has been greatly wasted by protracted illness, or exhausted by over-exertion of any description, whether of the nervous or muscular organs. It is related by Sir Nathaniel Wraxall, that in 1796, after many days of intense anxiety and mental exertion in Parliament, Mr. Pitt drove out to Wimbledon, where he slept above sixteen hours without interruption.

* In a late work, entitled *Psychology*, by Dr. Haddock, published by the Fowlers, the author maintains that "the insensibility of sleep is owing to a collapse, or falling together of the fibres of the cerebrum, *by which the blood is prevented from entering the finer channels of the brain, which has the power of imbibing or rejecting the vital fluids.*" This collapse is also caused, he says, by the manipulations of the mesmerist, who thus produces hypnotism.

Again, that the system actually increases in its dimensions during sleep, but diminishes while awake, and in a state of action, would appear from the fact, (which I have verified by numerous measurements,) that an ordinary-sized man is from eight lines to one inch taller in the morning, after a good night's repose, than in the evening. Some physiologists have maintained that this is owing to an expansion of the intervertebral cartilages, after the superincumbent weight of the body is removed, and to their compression when in the erect posture. But that it is owing to increased growth of the whole body, is proved by the smoothness and plumpness of the features and limbs, the rapid healing of wounds and the speedy recovery from the wasting effects of long illness, during and after sound repose,—by which the animal frame is filled with new life, exhaustion removed, the vivacity of the mind and the vigour of the muscles restored.*

Thus it is, that sleep is the "chief nourisher in life's feast;" and "a remedy for every curable disease;" as long ago observed by Menander. Nor is it less certain, that the whole body is wasted, and the features contracted, after long watching, by which the reparative powers of nature are diminished; and that nothing tends more effectually to injure the constitution than loss of sleep, by which it is rendered extremely liable

* Hippocrates seems to have understood that sleep is favourable to the nutritive process, for he observes, in the treatise on *Diet*, that it causes nourishment to unite with the body; and that loss of sleep impairs the power of digestion. (Lib. ii. sec. 121.) Aristotle also observes, that nutrition and growth are best performed during sleep, when all the higher faculties of our being are wholly inactive.

to the noxious influence of cold, malaria and other causes of disease. It is also worthy of notice, that young animals sleep more during the period of rapid growth, than after they arrive at maturity. Hence the remarkable activity and sprightliness of children, after the term of infancy is passed, and they have acquired the free use of their locomotive organs. In like manner, many persons who have attained their full growth, enjoy better health and spirits after great emaciation from severe illness and excessive medication, than they have had for several years before, provided no serious disorganization has taken place. The reason of which is, that after the body has been much reduced, and the disease arrested, the process of renovation by nutrition is more rapid than during an ordinary state of health; so that in respect to growth, intellectual vivacity and general excitability, the individual returns for a time to the charming condition of a new and youthful existence.

It is maintained by Edward Johnson and other physiologists, that nutrition goes on only during sleep. But I have proved, that during the contraction of every muscle, and during every action of every organ, there is an expenditure of substance and vital energy, in proportion to the activity of each; and that if not perpetually renovated by a fresh supply of arterial blood and vital heat, animal motion and all the operations of the nervous system are extinguished in a few minutes. So far is it from being true, that the formative process goes on only during repose or quiescence of the brain, nerves and voluntary muscles, that respiration and sanguification, secretion and nutrition,

are greatly augmented during violent exercise; for it is well known that the more vigorously any organ is exercised, the more abundantly is it supplied with arterial blood. Hence it is, that more food is required by men who take much exercise, than by such as lead a sedentary life. Yet, as the animal heat by which the organic particles of blood are united with the solids is more rapidly expended by exertion through the day, than it is obtained by respiration, the vital affinity by which the said particles are held in combination with the solids is very soon dissolved, when they are removed by the absorbents, and replaced by new ones, as shown in the foregoing parts of this work.

It is only, however, the brain, nerves and voluntary organs whose substance and power are so greatly exhausted by exercise; for, as the action of the lungs, heart, stomach, bowels and other involuntary organs is more nearly the same at all times, the process of renovation is generally equal to that of waste, and they never require absolute repose, but continue in action throughout the whole period of existence.

The most remarkable difference between exercise and sleep is, that during the former, the expenditure exceeds the income; whereas, during the latter, the income exceeds the expenditure. For example, if the annual income of an individual be five hundred pounds, and his expenses one thousand pounds, it is obvious, that unless the latter be materially diminished for a time, his whole capital must be very soon exhausted. In like manner, if the substance and vital heat of the body be expended by exercise of the brain, nerves and

voluntary muscles with twice the rapidity that they are replaced by respiration and nutrition, it becomes evidently necessary that the activity of the system should be suspended until the loss is repaired, which is most effectually accomplished during repose, when the expenditure is at the minimum. Thus it is, that although respiration is diminished 20 per cent. about the middle of night, even when awake, if the body be at rest, according to the experiments of Dr. Prout, and probably still more during sleep; yet the income greatly exceeds the waste. It is therefore manifest, that, in a philosophical point of view, sleep is the *birth*, and not "the death of each day's life," as maintained by Shakspeare; nor is it "death's younger brother," as asserted by Sir T. Brown.

That a larger amount of animal heat is retained in the body during sleep, *when sufficiently covered*, than during the exercise of the day, would appear from the fact, that the temperature under the tongue is one or two degrees higher on first awaking in the morning, than at bedtime; except after exercise or taking a hearty supper, both of which augment respiration. This explains why it is that in hot countries, where the inhabitants take an afternoon nap, as during summer in the United States, the face, neck and whole surface of the body perspire more than if awake at the same time, *cœteris paribus*. And Sanctorius informs us, that during seven hours sleep, the fluid exhaled from the skin of a healthy man was about double what was lost in the same time while he was awake. (*Med. Stat.* sec. 4.)

But as less caloric is obtained by respiration during

sleep than when we are awake, if the body be not well covered, it is more easily chilled, and the circulation depressed, than during exercise. Hence it is, that when exhausted by previous exertion, the caloric obtained by breathing is still more rapidly abstracted by exposure to cold and damp night air during sleep, than it is replaced,—by which the body is predisposed to a chill, which ushers in all the different forms of fever and other constitutional maladies. M. Quetelet states, in his recent statistical work on man, that the number of inspirations are diminished during sleep in the ratio of six to seven when awake, and the pulsations at the wrist, in the ratio of three to four per minute; that among three hundred individuals, at different ages, the extreme values were as represented in the following table. (See *page* 71.)

	Inspirations.	Pulsations.
At birth	44	136
5 years	26	88
15 to 20	20	69·5
20 to 25	18·7	69·7
25 to 30	16	71
30 to 50	18·1	70

But that the diminished frequency of the heart's action during sleep is owing to the cessation of voluntary motion, has been demonstrated by Dr. Knox, who found that in a healthy young man of regular habits, aged twenty, the average number of pulsations at seven in the morning was 7·4 beats greater than at ten in the evening, independent of food and exercise.

	Horizontal.	Sitting.	Standing.
Average morning pulse	62	78·3	90
Average evening pulse	56	67	77

He has further shown, that the excitability of the heart diminishes regularly from an early hour in the morning until midnight, when it is at zero. And I have found that the mean temperature under the tongue, *cæteris paribus*, is from 1° to 2° or 3° higher early in the morning than at midnight.*

As might naturally be supposed, Dr. Knox observed, that the action of the heart was greatly reduced by sitting in a cold room;† that its pulsations are most frequent in infancy, and diminish on till old age, when they are at a minimum; that they are more accelerated by food and exercise in the morning and during the forenoon than in the afternoon, and least of all in the evening—more in weak than in strong individuals—but that this does not apply to wine and spirituous liquors; finally, that the action of the heart is augmented more by muscular exertion than by fever or any other cause. (*Ed. Med. and Surg. Journal* for 1813–14–15.) Nor is this latter fact at all surprising, when we reflect that from three to four times more caloric is disengaged by respiration during active exercise than when we are at rest. Nor is it difficult to comprehend, why the action of the heart is more strong and frequent in the morning than evening,

* This fact is confirmed by the more recent observations of Dr. J. Davy, who found the temperature of the human body is highest in the morning, and that it remains high, but fluctuating, till evening, (being augmented by exercise, and after eating,) and lowest about midnight.

† Blumenbach says the pulse is slower in cold than in tropical climates, where the mean temperature under the tongue is about 2° higher than in England, as shown by Dr. J. Davy.

when we reflect that more animal heat is expended by exercise during the day, than is obtained from the atmosphere by respiration.

It is said by McNish, that birds sleep less than mammalia, and the latter less than man, who requires more during winter than summer, and more in cold than in hot climates. However this may be, it is certain, that during the long nights of winter, for some time before and after Christmas, the cock frequently crows at intervals, as if not disposed to sleep so long. During the prime of life, men require from six to eight hours sleep, if we except those of large chests, vigorous constitutions and sanguine temperament, who are able to endure great muscular and intellectual exertion with much less repose, than individuals of the phlegmatic temperament—doubtless because the nutritive or reparative process is more energetic in the former, and because their sleep is more perfect. During the most active period of their lives, Alexander, Julius Cæsar, Napoleon, Washington, the Duke of Wellington, Lord Brougham and many other distinguished men, have not slept above four or five hours in the twenty-four. But nothing tends more certainly to injure the constitution and shorten life, than a want of sufficient sleep, which is more essential to men of studious habits, and to such as take much laborious exercise, than to the idle and inactive. Bourrienne says of Napoleon, that he generally slept seven hours out of the twenty-four, besides taking a short nap in the afternoon. (*Memoirs of Napoleon.*) Owing to imperfection in the nutritive process, sleep is less sound and refreshing in old age, than during the earlier periods of life.

Whatever diminishes the circulation of arterial blood through the brain, and thus impairs its vital activity, tends to produce drowsiness. For example, it is often induced by a full meal, which causes a determination of blood and vital heat from the brain and other organs to the stomach, for the purpose of supplying it with gastric juice, during the process of digestion; causing sleepiness, languor and chilliness in feeble constitutions. Hence the impropriety of taking late and hearty suppers, (especially after a full dinner,) the digestion of which during sleep requires a large supply of blood in the stomach, *at a time that it should be employed exclusively in repairing the previous waste of the solids*, which, as we have seen, is the principal object of repose. The nutritive properties of the blood are also impaired by the mixing of fresh chyle with it, which is the reason that sleep is less sound after full than light suppers; and that more of it is required to refresh and renovate the body. It is less refreshing on hard than on soft beds, because the weight of the body presses on a larger surface of the latter, and the rest is more complete. It is a savage custom, that of making children lie on hard beds, which do not contribute to vigorous health; and have been found injurious to the shape of infants.

Sleep is frequently induced by a glass of negus or warm spirits and water, which also produce a determination of blood from the brain to the stomach—and by hearing a dull monotonous discourse, which nearly suspends the train of one's own thoughts, without being interesting enough to maintain the activity of the brain. Sleep is also induced by exposure to the

air of a heated room, which causes a determination of blood to the surface, at the expense of the brain, muscles and other important organs. Hence it is, that the most delightful of all soporifics is the warm bath, especially after exposure to cold and fatigue, as it removes the stiffness, soreness and aching, which sometimes prevent sleep when most required. But excessive external warmth is unfavourable to sound sleep, because it raises the temperature of the solids nearly to an equilibrium with that of the arterial blood, by which the combination of its particles with the solids is diminished. Hence it is, that when oppressed with too much covering, we feel languid and unrefreshed on rising in the morning, until the body is washed with cold water; and that men sleep more soundly in temperate than in hot climates, where nothing more conduces to healthful repose than cooling ablutions, or the tepid bath, before going to bed.

Whatever greatly diminishes the nutritive process, tends to prevent natural sleep, which is therefore always imperfect, if not wholly interrupted, during fever, and many other forms of disease. It is also frequently prevented by over-activity of the nervous system, caused by mental anxiety and too intense thinking, which interfere with the nutritive process, and induce a feverish state of the brain, that may be relieved by cold applications to the head, putting the feet in warm water and then getting into a warm bed —all of which tend to equalize the circulation, diminish the morbid activity of the brain and thus induce sleep.*

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* Raspail is said to have discovered that one grain of camphor,

It is maintained by Dr. Billing, that a warm bed is favourable to sleep, by causing a *plethoric state of the brain.* (*Principles of Med.* p. 80.) But according to the observations of Blumenbach, the circulation is diminished in the brain and its *vessels are less turgid* during sleep than when we are awake. Hence it is, that strong tea and coffee prevent sleep, by augmenting the circulation and activity of the brain, (perhaps also by impairing the nutritive properties of the blood;) or that when the blood is determined from the surface and extremities, by sleeping in a cold bed, and sent to the brain in augmented quantities, we are kept awake until the circulation is equalized by warmth. Sleep is more sound during the early part of night, when the nutritive process is actively employed in repairing the previous waste, than toward morning, when it is often partially interrupted by dreams. Long before the philosophy of mind had been rescued from the reveries of metaphysics, by the discoveries of Dr. Gall, it was known that the different senses sleep in succession and with different degrees of intensity; that in cases of partial somnolency individuals are capable of hearing and even of answering questions, when vision and all the other senses are quiescent; that sleep-walkers perform many extraordinary feats of muscular and mental exertion, of which they remember nothing afterwards. But this inquiry cannot be further pursued at present. It may, however, be observed, that night-

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formed into a pill, and followed by a draught of one and a half ounces of the infusion of hops, mixed with five drops of ether, will procure sleep when all other narcotics fail, even in cases of approaching insanity.

mare is owing to a temporary obstruction of the general circulation, caused by overloading the stomach, or by the intemperate use of spirituous liquors; both of which prevent sound and refreshing sleep; while they induce a lethargic state of the system, as shown by the torpor of the boa constrictor when gorged with an enormous meal, by some savage tribes, and by nearly all intemperate persons.

As for plants, they require no sleep, because they suffer no loss of their substance and vitality by exercise, therefore have nothing to do but to grow. The drooping of the leaves which takes place in a few of them when deprived of light, is owing to a diminished circulation of sap through their vessels, and is no more entitled to be regarded as sleep than the folding up of the leaves that takes place in some plants, under the scorching influence of a burning sun, which causes their fluids to be carried off by evaporation faster than they are supplied by the soil.

Nor must we confound the lethargy of hybernating animals, (during which the temperature falls to that of the surrounding medium, or nearly so, and all the functions of life are arrested or greatly diminished, with natural sleep; for what the ancients called the *vital* and *natural* functions, Harvey the *vegetative*, and Bichat the *organic* functions, still continue to go on, while the temperature remains at the healthy standard. But hybernation consists in a diminution or temporary suspension of vitality, which, as we have seen, is augmented by genuine sleep. Nor must we confound the sweet restorer of nature and "balm of hurt minds," with the stupor of apoplexy, epilepsy, trance, typhus

and other forms of malignant fever; all of which are attended with diminished respiration, sanguification, nutrition and growth. The blood being imperfectly renovated and supplied with caloric in the lungs, becomes of a dark colour even in the arteries, and therefore unfit to maintain the activity of the brain, which falls into what Dr. Billing very aptly terms "the coma of inanition." The same condition is induced by excessive loss of blood, a large abstraction of caloric from the body, the inhalation of mephitic gases, the use of opium and other narcotics, or by whatever greatly diminishes respiration, the vital properties of the blood and its power of nourishing the solids.

INFLUENCE OF THE MIND ON HEALTH.

Nothing contributes more essentially to health and longevity than a happy and tranquil state of mind, which must be sought in a temperate exercise of all the physical, intellectual and moral faculties. Benevolence, friendship, love, a good conscience, with tender, refined and elevated thoughts, are never-failing sources of health, beauty and delight; whereas pride, envy, jealousy, covetousness, anger and all the passions, when habitually indulged to excess, not only embitter our own happiness and that of all around us, but sap the foundations of health, mar the human face divine and shorten the period of existence. It is therefore manifest, that the connection between vice and misery, virtue and happiness, depends on the radical laws of our organization, which cannot be violated with impunity; and that a due regulation of the passions is no

less important to our well-being, than temperance in eating, drinking, muscular exercise, &c.*

That the forces of life are greatly modified by conditions of the brain and nervous system, is evident from the fact, that respiration, on which they all depend, is a voluntary process, which is excited to increased activity by hope, love, joy, confidence and whatever tends to excite pleasurable emotions; the lungs expand with freedom, by which the blood is abundantly supplied with caloric, converted into a bright scarlet fluid, the force of its circulation is augmented, digestion, sanguification, nutrition and all the other functions of life are performed with alacrity. But when the brain is paralyzed by grief, fear, despair,

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* Dr. James Johnson observes, in his treatise on the *Economy of Health*, that a great majority of our corporeal disorders, in the present state of civilized society, spring from or are aggravated by mental perturbations; that the passions are the tempests of life, which too often set at defiance the rudder of reason, driving the vessel on shoals and quicksands and ultimately wrecking it altogether; that the bench, the hustings, nay, even the pulpit, pour forth the destructive elements of discord; that the fury of political strife, the hazards of commerce, the jealousies, envies and rivalries of the professions, the fear of poverty, the terrors of superstition and the hatreds of sectarianism, are perpetual sources of ill health and a long train of moral evils; that nearly all the causes of nervous maladies may be traced to *anxiety of mind, intensity of thought, sedentary avocations and plenary indulgence;* that the besetting sin of the present age is not so much that of intemperance in eating and drinking, as reading and thinking; the penalty of which, alas, falls far more frequently on those who labour for the good of society, than on those who live in luxury and idleness. But he adds, of the mode in which the mind operates on the body, we know as little as we do in regard to the *modus operandi* of gravity and magnetism. (*Pages* 134, 146, 150.)

or by the repeated shocks of adverse fortune, its voluntary power is diminished, as if by a blow on the head, so that the individual almost forgets to breathe, until a feeling of oppression warns him to take a deep inspiration, which is only another name for the boding sigh.*

The supply of animal heat by respiration is diminished, the action of the heart enfeebled, the circulation through the lungs and general system is languid, the extremities are cold, perspiration is checked, the surface is pale or sallow and the internal organs are congested with *dark venous blood*, which was called *black bile* by the ancients, who regarded it as the cause of the melancholy temperament. They also knew that happy emotions induce a bright arterial hue of the blood; for Homer speaks of *florid joy*, and Hippocrates of *black melancholy*. Respiration is no less certainly diminished and the vital properties of the blood impaired, by the depressing passions, than by the influence of an impure atmosphere, an impoverished diet, too much or too little exercise, intemperance in the use of spirituous liquors and mercurial salivation, as proved by the experiments of Dr. Prout.

The natural consequence of such a state of things is, that all the secretions are deranged; and the nutri-

* The immediate cause of yawning is fatigue or exhaustion, especially of the brain, and it is most easily produced in persons whose nervous system is in a feeble state. It is, therefore, a sign of drowsiness, and generally precedes an attack of fever. The yawn itself consists in a deep and slow inspiration, prompted by the instinctive feeling of a vital want, and the tendency of which is to supply that want by augmenting the process of breathing.

tive properties of the blood being diminished, it unites imperfectly with the solids. Dr. Cheyne observes, "the juices of the body are always in a highly deranged and disordered state whenever those violent passions of grief, revenge or love exist, which absorb the unhappy patient." And Plutarch justly remarks, that the influence of an envious person disturbs and injures others both in mind and body, especially such as are feeble. I have also frequently been mesmerized by stupid company, until scarcely able to utter a sentence or to digest my dinner. On the other hand, I have been often so excited by the influence of an intellectual companion of large and generous heart, as to feel a delightful expansion of my whole being, both physical and mental. So that a portion of the caloric which ought to be employed in that process and in maintaining the secretions, is given out in the free state, causing a low fever and more or less debility of the brain, stomach, bowels and of all the organs. In this way is laid the foundation of dyspepsia,* costive-

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* The great mistake of Abernethy and many other modern pathologists, was in supposing that dyspepsia is a primary disease, and that all the complicated symptoms attending it are owing to sympathy of different parts of the body with some deranged condition of the stomach, which has been aggravated in many thousand cases by the blue pill, black draught and other pernicious drugs. It is true, that the disease is frequently brought on by gluttony and the excessive use of spirituous liquors; but it is much oftener the consequence of grief, anxiety, disappointment, uncongenial employment, too much or too little exercise, exposure to vicissitudes of weather without sufficient clothing, and frequently by the imprudent use of cold drinks, when the stomach is weak. That the proximate cause of the disease depends chiefly on dimi-

ness, hysteria, amenorrhœa, low spirits, habitual melancholy and torpor of all the organs; not, however, because "they are supplied with a vitiated nervous fluid," but because they are supplied with imperfectly arterialized blood, which, as I have already shown, is even more essential to the healthy activity of the brain and nerves, than to that of any other tissue. Bright and sound blood is essential to clear, strong and elevated thoughts; whereas dark and imperfect blood is the source of feeble, obscure and mystical ideas, which are the offspring of bodily disease or of an unbalanced state of the brain.

In accordance with the hypothetical views of Hoffman and Cullen, Dr. James Johnson tells us, that "the brain presides over *and furnishes energy to every other organ in the body.*" (*Op. cit.* p. 13.) And Dr. Andrew Combe observes, that "changes in the quality or amount of nervous influence transmitted from the brain to any organ, have a direct power of modifying its function; that if by some violent emotion of fear or grief, the brain be inordinately excited, so as to send forth a stimulus vitiated in quality, the stomach, which receives it, will partake of the disorder, causing

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nished respiration, circulation, secretion and nutrition, is evident from the fact, that the patient often complains of cold extremities, succeeded by more or less fever, pains in the head, back and limbs, giddiness, stupor and general debility, attended with an indisposition of wounds and ulcers to heal kindly, or a diminution of the *vis medicatrix naturæ;* symptoms that obviously require the warm bath, moderate exercise, warm clothing, pure air, nourishing food, agreeable company, with whatever is calculated to augment the circulation and improve the vital properties of the sanguineous fluid.

the loathing or sickness so often induced by unexpected bad news." (*Principles of Physiology*, p. 279.)

Many others maintain with Bichat and Richerand, that the organs of digestion, circulation, secretion, &c. are supplied with vital energy by the ganglionic system of nerves. But I have shown in a preceding chapter, that so far as respiration depends on the voluntary power of the brain and medulla oblongata, (exerted chiefly through the *nervus vagus*,) they are essential to the evolution of caloric in the lungs, sanguification, secretion, nutrition and growth, but no further. Hence it is, that division of the vagus of rabbits causes impeded respiration, a reduction of temperature and indigestion, as in the experiments of Dr. Philip; while other physiologists have found that it destroys life in a few days. But it was found by Sir Benjamin Brodie, that when the vagus was divided in young cats, near the cardia of the stomach and below the branch distributed to the lungs, the conversion of food into chyme and chyle was not prevented. It has also been well established by other experimenters, that the sensibility of a part may be entirely destroyed by dividing the nerves which go to it, without seriously impairing the nutritive process.

When the mind is overwhelmed with anxiety, grief, despair or some all-absorbing passion, it is no longer capable of exercising its accustomed voluntary power over respiration; on the due performance of which the vital properties of the blood and the healthy activity of all the functions depend. For it is certain that the life of the brain, spinal marrow, ganglionic nerves and every part of the body, is derived from the blood,

which derives it from the atmosphere, while passing through the lungs. It is therefore manifestly an erro to maintain that the brain or any other portion of the nervous system is the source of vitality; or that they exert any influence on the vital functions, except through the medium of the lungs, whose office in the animal economy resembles that of the sun in the planetary system.

Nearly the same effects are produced on the constitution of man by intense and long-continued study as by the depressing emotions; especially when the subject of inquiry involves at every step principles of the widest span, and therefore keeps the intellectual faculties on a perpetual strain.* Hence it is rare to find

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* The pathological history of literary and scientific men affords innumerable examples of the dangerous consequences arising from over-exertion of the intellectual faculties. No enlightened medical man can read the life and correspondence of Sir I. Newton, without being convinced, that for the space of two years he laboured under a state of partial insanity, brought on by his excessive devotion to mathematical and physical researches; aided, perhaps, by anxiety in regard to the extreme narrowness of his income. There is also evidence, that he was at times affected by doubts concerning the vacuum of space, the projectile force of planets, the inherent attractive and repulsive properties of atoms, as maintained in the *Principia*, which had been powerfully criticized by Leibnitz. In addition to all these causes, operating on a sensitive organization, he was annoyed by charges of infidelity, brought against him by Hutchinson and other fanatics of his age. Had not his labours been rewarded by a lucrative office under government, and crowned with glorious fame, it is probable that he would have sunk into a state of permanent melancholy, if not madness, and have died prematurely of apoplexy or paralysis, which carried off Sir Walter Scott in the sixty-second year of his age, notwithstanding the natural

the highest degrees of mental culture conjoined with vigorous health, except among individuals of large thorax. And even among the latter, the energy of the brain is maintained at the expense of the other organs and tissues. Like the bow, which loses its elastic force by being long bent, the power of the strongest mind is gradually impaired by intense thinking. And if not relieved by change of scenery and of occupation,* exercise in the open air, the occasional use of the warm bath, succeeded by a cold douche, light or agreeable amusements and the soothing conversation of congenial friends, it falls into a state of melancholy from which it never recovers; or is quenched by apoplexy, paralysis or madness, still more deplorable than premature death. Alas! how many precious lives have been sacrificed by an ardent zeal to benefit mankind; and some of them while attempting to unfold the laws of physical and moral health! But when the mind has been once kindled with a live coal from

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vigour of his constitution. Thus it is that the intemperate quest of knowledge often destroys its favourite votaries no less certainly than the depressing passions or excesses in eating, drinking and many other gross vices. But when science shall have been stripped of mystery and reduced to the simplicity of established principles, it will be only a healthful and delightful amusement to acquire a knowledge of whatever is essential to happiness.

* Change of ideas is as necessary to a perfectly sound state of mind, as variety of food to physical health. Great discoveries may be achieved by the cultivation of a particular talent; but the highest state of mental improvement requires the temperate exercise of all the intellectual faculties and moral sentiments in such a way as to produce the greatest amount of pleasure without fatigue or satiety, and maintain a due balance of the whole. Otherwise it is impossible to have "mens sana in corpore sano."

off the altar of God, and inspired with the animating hope of discovering truths more important than mines of silver and gold, it cannot pause in its onward career, until arrested by the approach of death or the failure of its powers.

It was observed by Madame De Stael, that "grief is not only a foe to intellectual fertility, but a *rapid poison:*" and, like fear,* it has been known to destroy life almost as suddenly as a dose of hydrocyanic acid. It also produces epilepsy and apoplexy, which are frequently brought on by over-exertion of mind, and depend essentially on a temporary paralysis or even lesion of the brain, by which respiration is nearly suspended, the power of the heart greatly diminished, and the vital properties of the blood so far impaired, that it becomes black even in the arteries, as shown by the livid or purple hue of the features. If in this state the chemical function of the lungs be not speedily restored by fresh air, artificial inflation or stimulants applied to the nostrils, and the circulation aroused by

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* In a conversation with Prince Metternich, the King of Naples said to him:—"Fear is a thing which lays hold of me in the head, and then it works in my chest, and then lower, until its effects are medicinal." Dr. C. Holland also observes, that fear produces diarrhœa and a flow of urine, showing that the bowels are debilitated, perspiration arrested and the bladder contracted. I have also seen a recent statement, on the authority of the London *Medical Times*, that in Russia four murderers were placed, without knowing it, in four beds, in which four persons had died of malignant cholera. They did not take the disease. They were then told they were to sleep in beds where some persons had died of cholera, whereas the beds were new, and had never been used at all. Nevertheless, three of them died of the disease within four hours.

the application of warmth, aided by friction, the patient sinks to rise no more. For so long as respiration and circulation are suspended, from whatever cause, blood-letting can be of no use.* In cases of compression and concussion of the brain, the symptoms are nearly the same as in the worst forms of apoplexy. The breathing is slow and stertorous, the surface and extremities cold, the pulse feeble, with prostration of strength, loss of appetite, nausea and suppression or derangement of all the secretions; showing that the voluntary power of the brain over respiration is impaired, and the circulation impeded. Owing to the

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* But it is not only by diminishing respiration, and thus impairing the vital properties of the blood, that intense thinking and the depressing emotions paralyze the energies of the brain, which is weakened by over-exertion, for the same reason that the voluntary muscles are exhausted by violent exercise. Judging from my own experience, I should say that *intense and long-continued action of the brain has a direct tendency to impede the nutritive process, by which its composition and power are perpetually renovated.* For I have observed in very many instances, after a few hours severe application, (especially when the general strength was much reduced,) that the forehead became feverish, and hotter than any other part of the body,—showing that the caloric sent to the brain, in combination with arterial blood, was not all employed and expended in maintaining the renewal of its substance and vitality. At such times, the circulation through the brain was so far impeded as to cause a preternatural throbbing of the carotid arteries; and the loss of mental power was often such as to prevent all successful exertion; but was uniformly more or less restored by the application of cold water to the head, moderate exercise in the open air, and the conversation of agreeable company. The most effectual method of prosecuting any literary or scientific enterprise which requires intense application, is to pursue the subject at leisure, so as never to induce exhaustion of the nervous system.

vitiated condition of the blood, it fails to unite with the solids; so that although less caloric is obtained by respiration than during health, it is not transferred to the solids, and expended in maintaining their activity, but accumulates in the body, causing the preternatural temperature of fever. Nor can the fevers thus induced be easily distinguished from such as are brought on by the influence of cold, miasmata, filth and a vicious or poor diet; but present the typhoid or inflammatory type, according to the greater or less injury of the brain, state of the constitution, &c.

It has been long known that during the prevalence of epidemics, fearful and desponding individuals, like those who have been weakened by intemperance, poor living, cold, impure air, and exhaustion from too much labour, are among the first to be attacked, and the most difficult to cure. *Nor is there anything in the whole Materia Medica so potent in the prevention and cure of disease, as a buoyant state of mind.* Hippocrates justly observes, that "the first duty of the physician is to inspire his patient with courage and consolation, which alone will often produce a cure." (*De Morbis*, lib. i. c. 2.) And it is certain, that a better knowledge of nature, as connected with the laws of health, would banish much of the idle terror that prevails among the people; and which is too often fostered by their spiritual leaders, *who ought to know that despair of recovery is the beginning of death.**

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* The influence of fear on the functions of animal life was well understood by Shakspeare:—

> "I have a faint, cold fear thrills through my veins,
> That almost freezes up the seat of life."

In those cases of partially suspended animation, termed trance, which occur chiefly in persons of weak or disordered minds, especially females of irritable constitution, the brain is paralyzed by over-excitement of the nervous system, caused by religious emotions of ecstasy, fear, &c. Respiration is so far arrested, that the temperature of the patient has been known to fall 20° or 30° below the natural standard, when the action of the heart becomes almost extinguished, the surface pale, and the individual exhibits scarcely any appearance of life. In many respects, the phenomena resemble the effects produced by the influence of what has been termed animal magnetism. After mesmerizing about one hundred persons of different classes, and both sexes, Dr. Sigmond states, that he found females much more easily affected by his manipulations than males; that in some, they brought on sleep or stupor—in others, fainting, hysteria, convulsions, and even trance; that respiration became imperceptible, the pulse feeble, the extremities cold and the features pallid; that in the case of a young lady in Fitzroy Square, it induced all the symptoms of suspended animation, which lasted four hours.* (*Lancet*, Dec. 9, 1837.)

The death of Madame Manchini, the sister of Cardinal Mazarin, had been foretold by her deceased husband, who was a great astrologer. And the prediction was doubtless the cause of its fulfilment, because, from the first moment of her last illness, she considered herself doomed, and actually expired at the very time foretold. (*Pardoe's Court of France*, p. 23.)

* Dr. Sigmond very justly refers the phenomena to diminished respiration; for he says, "the principle is precisely that of stealing the breath away." Yet he maintains, that "the act consists in

The function of respiration is diminished by swinging, whirling round or riding backward in a carriage, which interfere with the voluntary power of the brain,

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obliging the person to breathe again the carbonic acid previously expired." But this theory is quite as satisfactory and explicit as that of John Hunter, who defines trance as "the natural effect of a disposition in the person to have the action of life suspended for a time." (*Obs. on the An. Economy*, p. 109.) All such cases should be treated by first arousing the circulation by artificial respiration, the warm bath, friction, sternutatories, and afterwards prevented by avoiding the exciting causes,—not excepting the manipulations of mesmerism, which cannot fail to derange the healthy state of the nervous system in weak females.

The advocates of mesmerism admit that trance, sleep-walking, catalepsy, and other similar affections of the nervous system, are modifications of the same influence; and that it is seldom produced on persons in a state of vigorous health and sound mind. Under the name of witchcraft, the influence of animal magnetism was recognized by the ancients. Plutarch says that "the eye sends forth a strange fiery power, which operates greatly on weak, but less on strong constitutions; that something proceeds from the eye, whether light or a stream of spirits, by which the fire of love is kindled in the breast, and the soul of the lover seems to flow out, as it were, and to mingle with the object of his affection."

Dr. Paris justly observes, "a propensity to attribute every ordinary and natural effect to some extraordinary and unnatural cause, is one of the striking peculiarities of medical superstition." (*Pharmacologia*, vol. i. p. 17.) And M. Becquerel says, that whatever has been found most difficult to comprehend, men have latterly referred to electricity,—which has been supposed to be the cause of animal magnetism, and capable of enabling people to see without the organs of vision, to predict future events and to perform many other miracles. Yet we are told by Menzel, that "the discovery of animal magnetism is certainly one of the most important that was ever made, and does *especial honour to Germany*,"—while he ranks the discoveries of Gall with "the foolery of Lavater." (*German Literature*, vol. ii. p. 218.) That no material agent or fluid

causing giddiness, weakness, nausea, and sometimes fainting. Nor is it more strange that the passes of the animal magnetist should induce sleep, fainting and catalepsy, than that the rocking of a cradle should put children to sleep. Dr. Wollaston informs us that, while at sea, he caught himself holding his breath, as if waiting till the lurch of the vessel was over. And he very justly referred the languid action of his pulse, the great prostration of strength, together with the nausea and vomiting, to the influence of the ship's motion on the function of respiration. The natural remedy for sea-sickness is exercise, stimulating drinks and aliments; in short, whatever augments respiration and circulation, or the horizontal position, when exercise cannot be taken.

In feeble and irritable constitutions, the chemical function of the lungs is greatly diminished by painful

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is communicated from the operator to the patient, has been repeatedly demonstrated by the fact, that no impression is produced when the process is performed without his knowledge, or upon individuals who are unconscious of what is done. And that many of the cases on record are resolvable into the influence of the mind over the body, has been shown by making patients believe that they were mesmerized, when nothing of the kind was done, and thus producing all the pretended effects, without any intervention of the assumed cause; and by the counter-experiment of performing upon them the magnetic process without their knowledge, when no effect was produced. Prof. Bush regards mesmerism as a proof that the claims of Swedenborg to the power of holding communion with the spirits of another world are well founded. He observes, "if mesmerism be true, Swedenborg is right." But if mesmerism be a physiological or pathological process, the revelations of Swedenborg are reduced to natural laws, and thus removed from the sphere of metaphysics.

impressions made on the nervous system. It is well known that compound fractures, extensive burns, painful surgical operations and protracted labours, or even a painful prick of the hand or foot, are often followed by coldness of the skin, weak pulse, livid countenance, faintness, stupor, general prostration of the system, convulsions, and sometimes by death in a few hours. Many of the above symptoms have been caused in children by the irritation of teething, worms and the presence of indigestible matters in the stomach; but much oftener by inflammation of the glottis, which impedes the passage of air to the lungs, and destroys life by suffocation.

CHAPTER IV.

MODUS OPERANDI OF MEDICINES.

"Nonnulla symptomata non tam morboquam medico debeantur." —SYDENHAM.

A THOROUGH investigation of this important subject, under the guidance of broad and fundamental principles, would create a new era in medical science, and rescue it from the opprobrium of uncertainty which has long rendered its utility more than doubtful among men of the soundest views. It is still a question among physiologists, whether these agents operate primarily on the blood, as maintained by the humoral pathologists, or through the medium of the nervous system, by what has been called sympathy, as maintained by Stahl, Hoffman, Baglivi, Gaubius, Cullen, Brown and a large majority of modern authors. That the brain and nervous system are more quickly and powerfully affected by the mephitic gases and narcotic poisons than any of the other organs, cannot be denied. But we have already seen that all parts of the body are formed from, and vitalized by, the blood, which is absolutely essential to every operation of the animal economy, and more essential to the healthy activity of the brain than any other part of the system,—consequently, that whenever the

vital properties of the blood are impaired, the nervous system is the first which becomes diseased.*

It was long ago ascertained by Fontana, that opium, poison of the viper, ticunas and laurel-berry exert only a local influence on the nerves, and produce no general effects unless they enter the circulation. Sir Benjamin Brodie also found, that when the worara poison was applied to a wound in the forefoot of a rabbit, after all the nerves of the anterior extremity in the axilla of the same side were divided, the action of the poison was not prevented; but that when a ligature was placed around the leg of a rabbit, leaving out the principal nerves, no bad effects were produced by the poison, until the ligature was loosened, when they immediately ensued. (*Phil. Trans.* 1811, p. 178; 1812, p. 107.) He also found, that chloride of barium, tartar emetic and corrosive sublimate produced the same effects when applied to fresh wounds as when taken into the stomach; that, like arsenic, alcohol, oil of tobacco, oil of bitter almonds and other narcotic poisons, they are absorbed into the circulation, and produce their morbid effects by diminishing the voluntary power of the brain over the function of respiration. What is of vastly greater importance in a practical point of view, he ascertained, that *after respiration*

* For example, we have seen that about five times more blood is sent to the brain, in proportion to its weight, than to the body in general. The consequence of which is, that it is the first organ to suffer from loss of blood, or from whatever impairs its vital properties. Hence the prevalent opinion of pathologists, that the remote and exciting causes of fever produce their primary effects on the nervous system.

*and all the visible actions of life in a rabbit had been arrested by a dose of the oil of bitter almonds, they were restored by keeping up artificial respiration for sixteen minutes, and the animal appeared perfectly well in two hours.**

In accordance with the foregoing facts, we are informed by Müller, that in the experiments of Wedemeyer, the strongest prussic acid produced no sudden effect when applied to the nerves so as not to enter the circulation; that when Emmert amputated the

* We are informed by Mr. Morgan, of Guy's Hospital, that Mr. Sewell, of the Royal Veterinary College, inoculated a horse suffering from an attack of locked jaw, in the fleshy part of the shoulder, with an arrow-point coated with the ticunas, (which has been supposed to have the property of paralyzing the voluntary muscles, and thus of arresting spasmodic action,) when apparent death was produced in ten minutes; but that, on keeping up artificial respiration four hours, reanimation so far took place, that the animal rose up, seemed perfectly recovered, and eagerly partook of hay and corn, without any return of tetanus; yet died the next day. Mr. Morgan relates the case of an ass affected with tetanus, that was treated in the same way, with similar results; from which he was induced to recommend inoculation with the ticunas as a remedy for tetanus. But as it is certain, that nearly all the active poisons produce convulsions, I am fully convinced that, in the above cases of tetanus, the relief arose from the employment of artificial respiration, *in spite of the deadly poison:* for it will be shown hereafter, that in all the worst forms of tetanus and hydrophobia, the natural process of respiration is nearly suspended. I am the more disposed to attach the highest importance to artificial respiration, aided by the warm bath, in all spasmodic diseases, from the fact that they are always attended with difficult respiration, and a dissolved or greatly vitiated state of the blood, which is the proximate cause of all the most fatal forms of disease, and should be counteracted by restoring the process of respiration, by which the blood is formed and purified.

extremities of animals, leaving them connected with the trunk by the nerves only, and then introduced poison into the feet, no general effect resulted—nor even when applied to the nervous trunks themselves; that Viborg applied nearly a drachm of concentrated prussic acid to the brain of a horse, laid bare by means of the trephine, without the slightest symptoms of poisoning being produced; that Magendie and Delille divided all the parts of the thigh of a dog, except the crural artery and vein, which were dissected quite clean and freed from their cellular coat, to maintain the connection of the limb with the trunk—when two grains of the upas ticuti were inserted into a wound in the foot, the action of which was as rapid as if the limb had not been previously injured,—the first symptoms showing themselves in four minutes, followed by death in ten minutes.

We are therefore bound to admit with Müller, that the general effects of poisoning are produced by the entrance of noxious substances into the circulation, through which they operate upon the brain and nervous system.* He further states, that on applying

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* A still more decisive proof that poisons operate on the solid tissues through the medium of the fluids is, *that they destroy the life of plants, which have no nervous system*, as when they are placed in air containing small proportions of sulphurous, nitrous or hydrochloric acid, ammonia, carbonic oxide, olefiant gas, or in solutions of the vegetable, animal and mineral poisons. This has been fully demonstrated by the experiments of Macaire, Turner, Christison and other physiologists, who have also found that the *Mimosa pudica* and the *Berberis vulgaris* are killed much sooner by hydrocyanic acid than by solutions of opium, corrosive sublimate,

narcotics to the spinal marrow and nerves of frogs, no twitching of the muscles was excited, unless the poisons entered the circulation; yet he thinks their local action on the nervous system is proved by the influence of belladonna in dilating the pupil of the eye, and of lead in causing paralysis of the hands. (*Elements of Physiology*, pp. 238, 242, 628.)

That poisons operate on the nervous system through the blood, might naturally be inferred from the fact, that their effects are produced more rapidly on birds than mammalia and very slowly on cold-blooded animals, or whenever the circulation is languid, as in cases of nearly suspended animation from cold, or by inhaling carbonic acid. For example, it was long ago observed by Dr. Horsefield, that when fowls were wounded by arrows dipped in the chettick of Java, they died in one minute; and that much depends on the size of the animal, for when large, the poison is more diluted than when it is small; that the poison of the upas killed a mouse in ten minutes, a cat in fifteen minutes, a dog in one hour and a buffalo in two hours ten minutes. Similar results were obtained by Brodie, who also found that the narcotic poisons operated sooner on the brain, and thus arrested respiration, when applied to the tongue, than to the intestines, and sooner in small than large animals.

Müller relates that Hering found, from eighteen experiments on horses, that ferrocyanide of potassium mixed with the blood passed from one jugular vein,

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arsenic and arsenite of potash. But as the circulation of plants is less rapid than that of warm-blooded animals, so does it require a longer time for poisons to extinguish their vitality.

through the lungs and general system to the opposite jugular vein, in from twenty-five to thirty seconds; from the jugular vein to the great saphena in twenty seconds; from the jugular to the mesenteric artery in from fifteen to thirty seconds; to the facial artery, in one experiment, in from ten to fifteen seconds; and from the jugular vein to the metatarsal artery in from twenty to thirty seconds. Müller also states, from his own experiments, that coloured fluids pass through living membranes in one second, so as to be seen on the opposite side; and he thinks that the speedy effects of hydrocyanic acid are owing partly to its elasticity, by which it is rapidly diffused, absorbed into the circulation and thus conveyed to the brain and spinal marrow.

Mr. Blake has further shown, in a paper published in the *Med. and Surg. Journal*, vol. liii., and another in the *Lond. Med. Gazette* of June 18, 1841, that the rapidity with which poisons operate is in proportion to the activity of the circulation and the nearness of their application to the nervous centres; that hydrocyanic acid never produces its first symptoms sooner than nine seconds; that one grain of strychnia dissolved in a small quantity of acetic acid, produced convulsions in twenty seconds, when injected into the jugular vein of a dog, and apparent death in ninety seconds; that worara arrested the action of the lungs and caused apparent death in twenty-five seconds, when introduced into the jugular vein; that convulsions and death followed the insertion of conia into the femoral vein of a dog in thirty seconds; and that, in another dog, hydrocyanic acid passed from one part

of the vascular system back to the same part in from twelve to twenty seconds.*

When the narcotic poisons do not immediately destroy life, they produce small and difficult respiration, coldness of the surface, weak pulse, a pale or livid and ghastly expression of countenance, drowsiness, stupor, nausea, and sometimes vomiting; a dark and dissolved condition of the blood, prostration of strength, convulsions, and nearly all the symptoms which follow the inhalation of mephitic gases or an excessive loss of blood. And that they all operate by entering the circulation, is evident from the fact, that they rapidly disappear from a shut cavity, after which they are found in the blood and various secretions.† It has

* In a later series of experiments, published in the *St. Louis Medical and Surgical Journal*, November, 1847, Dr. Blake has shown, that when the above poisons are introduced into the veins or applied to the tissues, they produce their first symptoms on the horse in from sixteen to twenty seconds; on the dog, in from ten to twelve seconds; on the fowl, in about six seconds; and on the rabbit, in four and a half seconds; which he found to be the relative times required for the blood to complete the whole round of the circulation in these animals. From which he rightly infers, that poisons never act by a direct impression produced on the nerves of the part to which they are applied; but that they are conveyed to the nervous centres, through the medium of the circulating fluid.

† Tiedemann and Gmelin found verdigris and sugar of lead in the blood and veins. Wibmer detected copper in the liver; lead in the liver, spinal cord and muscles. Mayer found cyanide of potassium in the blood, serous secretions, and in various soft solids. Westrumb detected sulphocyanic acid in the blood and various soft parts of dogs, poisoned with that substance. Iodine has been found in the blood, sweat, urine, saliva and milk of patients who were using it medicinally. And many other similar cases might be

also been fully established by the numerous experiments of Magendie, Orfila, Thackrah, Dr. John Davy, Prater and other physiologists, that, when sufficiently concentrated, they greatly diminish the coagulating property of the blood, by dissolving its fibrin or by disorganizing its red particles; that after death, the lungs, brain and abdominal organs are found engorged with dark fluid blood, and the body soon putrefies. It is therefore evident, that if in small doses they alleviate pain, it is owing chiefly to their influence in diminishing sensibility, by impairing the vital properties of the blood; that if hydrocyanic acid relieves pain in the stomach, it is by inducing torpor of that important organ; and so of all the other narcotics.*

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adduced. Yet, owing to the small quantities that enter the vessels, and to the fact that in certain cases the poisons pass out of the body with the excretions before death, they cannot sometimes be detected. Some of them are decomposed in the blood, which they must also decompose by their action, which is the cause of their fatal influence. (See *Christison on Poisons*, p. 14 and elsewhere.)

* The influence of alcohol is very similar to that of opium and other narcotic poisons. It kills leeches in two or three minutes, and very soon destroys the life of plants. Like the strong acids and caustic alkalies, it produces rapid inflammation of the stomach, solidifies the albumen of the blood, arrests the process of breathing and causes all the symptoms of apoplexy, as proved by the experiments of Brodie on cats, rabbits and dogs. Orfila found that the injection of four drachms of pure alcohol into the veins of a dog was followed almost immediately by death. And that it impairs the vital properties of the blood when diluted, as in the form of spirits, wine or even malt liquors, is evident from its dark, grumous character and diminished power of coagulation, when drawn from the veins of a drunkard. The consequences of this are diminished respiration, cold extremities and shivering from slight ex-

Arsenious acid also, when applied to a fresh wound or taken into the stomach, causes short and hurried respiration, coldness of the surface, a pale or livid hue of the face, feeble pulse, vomiting, faintness, stupor, convulsions and death, when the stomach is found to exhibit decided marks of inflammation. In doses of from one-eighth to one-sixteenth of a grain, three or four times per diem, it has been often observed to produce nausea, vomiting, griping pains, headache, sweating, tremors, œdematous swelling of the face, hands and feet, spasms of the lower extremities, cutaneous eruptions and other symptoms of constitutional derangement. It should be banished from the Materia Medica. The effects of red or white lead when taken into the stomach, are diminished respiration, coldness of the extremities, small and slow pulse, nausea, cramps, torpor of the bowels, prostration of strength, partial paralysis, convulsions and death. The salts of copper are also followed by rigors, violent headache, loss of sensibility, vomiting, cramps, paralysis and death.

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posure, (when the influence of the stimulus has ceased,) a dirty or livid complexion, loss of appetite, impaired sensibility, torpor and congestion of the capillaries, attended with palpitation of the heart, imperfect nutrition, low spirits, giddiness, stertorous breathing, confusion of mind, softening of the brain, premature old age, sterility, madness, idiocy, epilepsy, paralysis, apoplexy and death Delirium tremens, the most common disease of drunkards, comes on with chilliness, weak pulse, nausea, great mental depression, general debility and a cadaverous expression of countenance, followed by imperfect sleep, frightful dreams, a dry and furred tongue, cold sweats, tremors, convulsions and sometimes death. Mr. Lay also describes the Chinese opium-eater as marked by a sallow visage, weak voice, ghastly features, emaciated limbs and tottering gait.

Corrosive sublimate produces nearly the same effects as arsenic, with still more decided marks of inflammation in the stomach. Like the chloride of tin, the chloride of barium, the subacetate of lead, the nitrates of copper and bismuth, it combines with and precipitates the albumen of the blood, according to Magendie, who recommends the white of eggs as an antidote when any of these poisons have been swallowed. He also found that seven grains of oxalic acid, when injected into the veins of a dog, caused difficulty of breathing, followed by death the next morning, when his blood was found in a dissolved state, as when mixed with the same poison out of the body. But a larger quantity is required to produce the same effects when taken into the stomach, because it is then more gradually diffused throughout the mass of the blood, and thus diluted. When half an ounce is swallowed, respiration is greatly diminished, the surface becomes cold and clammy, the pulse feeble or imperceptible, the countenance pale or livid, attended with nausea, vomiting, convulsions and death in a few hours, when the stomach is found in a state of inflammation.

Tartar emetic produces vomiting, purging, great debility, headache and often cramps, whether taken into the stomach or applied to a fresh wound. Magendie found that when from six to ten grains of it were introduced into the stomach of dogs, and the gullet tied, they died in from two to three hours; that when a solution of it was injected into the veins of a dog, it produced nausea after the stomach was removed, difficulty of breathing, cough, symptoms of

pneumonia, fever and death. He further states, that he has not found the exhibition of this medicine, in the treatment of pneumonia and rheumatism, to correspond with the accounts of Laennec; and that when mixed with very small proportions of blood, immediately after it was drawn from the body, it disorganized the red particles. We are also informed by Andral, that when six grains of it were given daily, in divided doses, to individuals labouring under the milder forms of pneumonia, the disease gradually assumed the character of malignant typhus. And there is reason to believe that, if all physicians had recorded their observations with the same intelligence and fidelity, many thousand similar cases might be adduced.

The operation of an emetic is attended with all the leading symptoms of intermittent fever. Its first effect is to weaken the capillary vessels of the stomach, by impairing the vital properties of the blood; to arrest the secretion of gastric juice and cause a tendency to inflammation of that important organ. The shock thus imparted to the general system diminishes, to a greater or less extent, the function of respiration, as shown by a slight sensation of chilliness soon after the medicine is taken, followed by a small, frequent and irregular pulse, headache, dimness of vision, lowness of spirits and universal debility, until a spasmodic state of the stomach is induced and its contents are discharged by vomiting. But as this stage of depression is attended by a diminution of nutrition and of all the secretions, the vital heat obtained by breathing is not transferred to the solids, but accumulates in the

blood, causing a temporary fever; for it was found by Dr. C. Holland, that soon after it produced vomiting, the temperature under his tongue rose from 97° to 100·5°, (the air being at 59·5°,) and his pulse from 77° to 100°.* This elevation of temperature augments the action of the heart, by which the blood is sent into the extreme capillaries of the whole body and perspiration induced, when the paroxysm terminates and the various functions gradually return to their former state, which it generally requires two or three days for them to regain.

Thus we perceive that tartarized antimony (and the same is true of all other emetics) produces, in a mitigated form and for a short time, the *cold*, *hot* and *sweating stages*, of intermittent fever; consequently, that it operates in the same way as malaria and other morbific agents. It is, therefore, not surprising that, when given in small doses for several days in succession, it generates malignant typhus, as proved by the experiments of Andral and other pathologists.† But

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* He says, that forty-five minutes after taking four grains of tartar emetic and twenty grains of ipecac., the temperature under the tongue of Mr. Buchan fell from 98° to 96°, (that of the room being 63·5°,) but that after vomiting several times, his temperature rose to 99° and the pulse from sixty-six to seventy-seven beats per minute. (*Laws of Org. Life.*)

† It is obvious that when tartar emetic is taken in large doses, it is less dangerous than in smaller ones, because, in the one case, the greater part of it is soon expelled by vomiting and purging; whereas in the latter case, it is nearly all absorbed into the blood, the red particles of which it dissolves and thus impairs its vital and nutritive properties. We have already seen, that when only six grains were introduced into the stomach of a dog and the œsopha-

if the object be to excite perspiration, why employ a medicine that does so by impairing the vital properties of the blood and by generating more or less fever? Is not caloric the most certain, agreeable and salutary of all the sudorifics and diaphoretics, when employed externally and internally? Does it not increase the vigour of the circulation through the lungs when torpid, and thus improve the vital properties of the blood? Is it not the agent on which all the phenomena of life and health depend? Why then resort to the use of a drug, the obvious tendency of which is to *diminish* all the powers of life,—except when it is necessary to relieve the stomach from an accumulation of morbid or indigestible matter, which may be accomplished far more safely by copious draughts of lukewarm water, and tickling the throat with a feather?

Perhaps there is no article in the Materia Medica that has been more extensively employed than mercury, in various forms, *which, there is reason to believe, has destroyed more constitutions than even malaria;* for, although the mode of its operation is still involved in mystery, it is given in almost every form of disease. It has long been regarded as a specific remedy in syphilis; but, fortunately for mankind, physicians are now beginning to learn that this disease may be cured without mercury; and that it rarely proves dangerous, except when aggravated by the abuse of that mineral, to which the worst forms of

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gus was tied, so as to prevent its expulsion, death was produced in three hours. What then can justify the practitioner who gives his patient from two to six grains of this medicine daily, in broken doses?

what has been called secondary syphilis are now justly ascribed.*

It was the opinion of John Hunter, that mercury cures syphilis by creating another disease, which, being incompatible with the primary one, overcomes and removes it. But this is obviously no explanation. And there is reason to believe, that it operates either by combining with and neutralizing the syphilitic virus or by diminishing the nutritive process, and thus enabling the absorbents to remove chancres, buboes and other glandular enlargements. Dr. Billing maintains very justly, that both mercury and iodine remove morbid growths by starving them.† In favour of this

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* In his *Lectures on Surgery*, Sir Astley Cooper observes, that in a healthy person, the venereal disease is slow in its progress, and attended with little inflammation; but that in an irritable person, it is rapid in its progress and accompanied by considerable inflammatory action; that mercury itself unfortunately produces diseases very similar, both in appearance and effect, to syphilis; that he once had a patient whom he regarded as "poxed up to the eyes," and who was entirely cured without mercury, by using the warm bath, at the sea side.

† In a late treatise on the *Mercurial Disease*, by Dr. Dietrich of Munich, we are informed that it is attended with a sensation of coldness, which is followed by alternations of feverish dryness and profuse sweats, with salivation, a dissolved condition of the blood, great prostration of strength, diarrhœa, hæmorrhages and cold sweats,—when mercury may be detected in all the secretions, or by rubbing against the skin a piece of copper, which becomes white; that if not carried out of the body through the different emunctories, it produces ulceration of the soft parts and swelling of the bones, or disease of the periostium; that the worst forms of the disease are attended with softening of the brain, paralysis, apoplexy, madness or loss of mental power, dropsy, rapid emaciation, subsultus tendinum, hectic fever and death. Alas! how many

opinion, it is well known that tartarized antimony and other emetics, (which operate by arresting or diminishing the nutritive process,) cause the removal of buboes, swelled testicle, effusions of lymph, serum, &c.

The general opinion is, that mercury, iodine, digitalis and some other medicines, produce these effects by augmenting the activity of the absorbents; whereas they operate by diminishing the process of nutrition, while that of absorption continues to go on; causing a more or less rapid waste of the whole body, by which effusions and morbid growths are removed.* It is in

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thousand lives have been sacrificed by the abuse of this slow but certain poison! When speaking to his class on the abuse of mercury in the South, Dr. Chapman observes: "It is a disgraceful reproach to the profession of medicine; it is quackery, horrid, unwarranted, murderous quackery." Nearly the same fatal effects are produced by the long-continued employment of iodine, which sometimes causes vomiting, purging, small pulse, fever, cramps, colic, rapid emaciation and death, when it is found in the blood, milk and urine of the patient. We are also informed by Orfila, that four grains of iodide of potassium, when injected into the jugular vein of a dog, caused convulsions and death in about one minute. That mercury induces ptyalism by weakening the capillaries of the salivary glands, would appear from the swelling, inflammation and often mortification of those glands, which result from its use.

* It is maintained by medical authors of high repute, that salivation is useful in fever, by preventing the nutritive process. But I have proved that the proximate cause of fever, and in reality of all the other forms of disease, is a derangement of the nutritive process; and we have just seen that the use of mercury induces hectic fever. This fact was noticed by J. Hunter, who says, "that it quickens the pulse, increases its hardness and occasions a kind of temporary fever." (*On Vener. Dis.*, p. 340.) Why then give a medicine which produces the very symptoms we wish to counter-

this way that small doses of calomel have been supposed to be useful in removing the effects of chronic inflammation of the larynx, trachea and bronchi, when attended with an effusion of lymph and a thickening of the mucous membrane. Thus it is by giving a preponderance to the lymphatic absorbents over the nutritive process that such medicines produce their effects. Nor can there be a doubt that nearly all the more active articles in our Materia Medica impair the vital properties of the blood, and, relatively, increase absorption.

For example, it was found by Orfila, that on injecting a drachm of the liquor ammoniæ into the jugular vein of a strong dog, convulsions immediately followed, and death in ten minutes. The same effects are produced in a much shorter time by injecting a few grains of caustic potassa into the veins of a dog. Liebig maintains that alcohol and most of the neutral salts operate by abstracting water from the moist tissues.*

act and remove? Yet there is reason to believe, that when given in four-grain doses every four hours through the day, and followed by some more brisk cathartic, calomel is an excellent remedy for the removal of morbid excretions from the alimentary canal. I cannot, however, subscribe to the prevalent doctrine of the schools, that it increases the secretion of bile; an opinion which seems to have arisen from the fact, that, like many other medicines and morbific agents, it arrests or greatly diminishes the process of digestion; so that there is but little chyme formed to unite with the bile, which, therefore, seems to be more abundant than usual. What the celebrated Porson said of sea bathing in England, applies much better to some of our *heroic* medicines, that "it had been regarded as salutary, because many have been known to survive it."

* Poiseuille found that there was endosmose through animal tissues from the serum of blood to Seidlitz water, and saline solu-

But we have seen from the experiments of Magendie, (referred to in a note to *pages* 595–6 of this work,) that when mixed with fresh blood as soon as taken from the body, they all prevent or greatly retard its coagulation. He also found that very small proportions of the carbonates of soda, potassa and ammonia, nitrates of potash, lime and other alkalies, produced the same effects; that soon after injecting less than an ounce of carbonate of soda into the veins of a dog, he was attacked with dyspnœa, small and frequent pulse, prostration of strength, congestion of the lungs and abdominal viscera, effusions of blood and all the symptoms of malignant typhus fever.* It is, moreover, certain, that when taken into the stomach daily in small doses for a considerable time, they induce great emaciation, a dissolved condition of the blood, and many of the symptoms that characterize scurvy. Many of them operate as diu-

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tions; but that when hydrochlorate of morphia was added to the same solutions, the endosmose was very much weakened and the direction of the current ultimately changed. Hence the reason, that when taken internally, salts produce copious serous discharges, containing albumen; while morphia and other preparations of opium check diarrhœa, dysentery, and produce constipation. (Mateucci, *Phenomena of Living Bodies*, pp. 73, 74.)

* Magendie further ascertained, that by introducing a portion of finely powdered potato starch into the carotid artery of a dog, he was attacked with dyspnœa, cough, prostration of strength, diarrhœa and fever; that when he injected a drachm of varnish, holding some sifted pulverized animal charcoal in suspension, into the femoral artery of another dog, after tying it, the limb became swollen below the ligature, cold, motionless and insensible, followed by extravasation of blood into the cellular tissue, obstruction of the capillaries and gangrene.

retics merely from their refrigerating influence, by which perspiration is checked and the amount of urine proportionally augmented. But when taken with hot drinks they sometimes operate as diaphoretics. A vast amount of mischief is produced in the United States, by the employment of alkalies in bread, which has been often observed to cause disorder of the stomach, sore mouth and other morbid effects. By neutralizing the acid of gastric juice they impair digestion. The truth is, that all emetics are purgative, when taken in small doses; and that all purgatives excite vomiting, when given in large doses.

From the foregoing brief and imperfect examination of this important subject, it is evident that nearly all the most active articles employed in the treatment of diseases are more or less hostile to the animal economy, as maintained by many of the most enlightened physicians of ancient and modern times. The ablest writers on Materia Medica admit that, like the various causes of disease, their effect is to produce an excitement of the system, or some portion of it, above the healthy standard, or a depression below that standard; both of which are abnormal and therefore morbid. There is reason to believe that the prevalent abuse of emetics and purgatives has been owing in part to the erroneous opinion of the Greeks, that the proximate cause of fever and other forms of disease is a superabundance of bile, which ought to be carried off. Yet Hippocrates often cautions us in regard to their debilitating influence, especially in acute diseases and during the relaxing heat of summer. He further states, that in some cases the death of his patient seemed to

be hastened by the violent operation of the medicines which he prescribed. (*Epidemics*, book v.) It was the opinion of Erasistratus that *purgatives first produce the bad condition of the humours which they afterwards bring away.* Asclepiades also maintained, that whatever good resulted from their use was so far balanced by evil that they should be rarely given, but instead of them injections. It was an important axiom with him, that disease should be cured safely, speedily and pleasantly: *tuto cito, et jucunde.* (Celsus, lib. iii. c. 4.)

This is one of the finest general axioms that has been transmitted to us by the ancients, and is worthy of Hippocrates himself. For the *safest* method of treating any disease is to begin with it early, by which it may be arrested and cured *very soon* and without the employment of harsh or disagreeable remedies, which are apt to *prolong* it and often endanger the safety of the patient. The truth should be no longer disguised, that a large majority of our active medicines operate as predisposing and exciting causes of disease, by weakening the stomach, bowels, brain, voluntary muscles, deranging the nutritive properties of the blood and depressing all the forces of life. It must also be admitted, that instead of being *pleasant* to take, most of them are extremely repugnant to nature.

There is something calculated to arrest the attention of our profession in the following sad confession of Dr. Faustus, by Göethe, if it be lawful to pry into the secrets of the prison-house:—

"Thus with our hellish drugs, death's ceaseless fountains,
In these bright vales, o'er these green mountains,
Worse than the plague we raged:
I have myself to thousands poison given,
And heard their murderer praised as bless'd by heaven,
Because with nature strife he waged."

Even Dr. Cullen tells us, in his work on the *Practice of Physic*, that a purge often brings on a relapse of intermittent fever, after the paroxysms had ceased. The doctrine of Broussais, that all fevers depend on inflammation of the stomach and bowels, was partial and erroneous; yet it had the good effect of lessening the use of emetics and purgatives, which, although sometimes useful in removing morbid accumulations, often aggravate the disease.* And although the homœopathic theory be founded on a series of hypotheses

* The late Dr. M'Culloch was still more opposed to the use of emetics, cathartics and other active medicines, which, together with blood-letting, he ranks among the principal causes of disease. Dr. W. Stevens also thinks, that patients labouring under fever in the West Indies, have a much better chance of recovering when left to themselves, than when treated with emetics, calomel and opium, which add greatly to the suffering of the patient and to the mortality of hot climates. (*Medico-Chirurg. Rev.*, July, 1830.) And Dr. James Johnson observes, that "in a great majority of the mild fevers in temperate climates, it is probable that nature would be more successful than art or the farrago of medicines prescribed by the routine practitioner." But he facetiously adds, "let not this, however, be told in Gath." And he very properly ridicules the prevalent self-quackery of taking calomel, or some other mercurial preparation, for the removal of what is called *biliousness*. During the prevalence of epidemic cholera in the United States, many cases were immediately brought on by taking a drastic purge, with a hope of preventing the disease.

that explain nothing, the infinitesimal doses of medicine which it prescribes are harmless and afford nature an opportunity of curing the disease.* Yet its votaries are chargeable with leaving undone many important things which ought to be done.

In a practical point of view, *caloric*, *air* and *food*, are of infinitely more importance, in the prevention and treatment of diseases, than all the articles of the Materia Medica; because they are the natural agents by which all the healthy operations of life are maintained. Next to these, are the artificial stimulants, such as wine, spirits, ether, ammonia, the essential oils, balsams, spices and terebinthinites,—all of which owe their active properties to the large amount of caloric which they contain, (and probably to the combination of their carbon and hydrogen with atmospheric oxygen, by which heat is evolved,) as shown by the hot and burning sensation they produce in the mouth and stomach. Hence it is, that when the powers of life are reduced below par, they are often useful in restoring the circulation to its natural vigour.

It is also worthy of notice, that the stimulating influence of the Spanish fly, mustard, turpentine, pitch and many other external applications, is owing chiefly, if not wholly, to the heat which attends their opera-

* After all that Hahnemann says concerning the potency of his medicines and the new degree of power which they acquire at each dilution, by the rubbing or shaking they undergo, he frankly observes, "*Si non juval, modo ne noceat.*" (*Organon*, p. 187.) The influence of faith on the curative powers of nature, is attested by the millions who have been cured by amulets, incantations and secret nostrums, whose efficacy was miraculous until their composition was exposed.

tion. It has been generally supposed that blisters and rubefacients relieve internal inflammations and congestions by acting as revulsives and evacuants. But the same beneficial effects are produced by the permanent application of a heated iron or vessel of hot water, without any evacuation of serum and lymph. I am therefore inclined to believe, that they operate by augmenting the partially suspended circulation of the capillaries, which is the proximate cause of inflammation. As for the balsams, they stimulate the mucous membranes, which, in chronic catarrh and gonorrhœa, are in a weakened state.

The opinion of Cullen, that Peruvian bark and other tonics render the tissues more firm and augment their cohesion, has been rendered highly probable by the researches of Dr. Adair Crawford, who maintains, in his *Experimental Inquiry into the Effects of Tonics*, that their operation is chiefly mechanical and owing to their astringent properties. Should it be objected that alum, acetate of lead and many other astringents, are greatly inferior as permanent tonics to the cinchona and other bitters, pepper and spices, I answer, that the former operate as poisons, and gradually impair the vital properties of the blood; whereas the latter remedies do not produce this effect. It is consoling to find that the most agreeable of all remedies are the most speedy, efficacious and safe, in the prevention and treatment of diseases. For example, what is so pleasant and effectual in arresting and preventing the chilliness by which they are all ushered in, as the warm bath, hot drinks and the application of dry heat? or when the temperature has been raised above

the natural standard, what so delightful and salutary as fresh air, with cooling drinks and ablutions? There is reason to hope, that the time is not distant when the various morbid conditions of the body will be counteracted and removed by regimen, exercise, a judicious occupation of all the faculties, warm and cold bathing, improvement of the social system in every respect; that health will be preserved by a right knowledge of whatever modifies the vital functions, whether in health or disease, without resorting to poisonous drugs; that except in surgical cases, every one may be his own physician, and a far more efficient one than any of those who now belong to the medical profession.

CHAPTER V.

THEORY OF TEMPERAMENTS.

"The moderns have neither by observation extended the ancient distinctions of temperaments, nor, though they have attempted it, have they ever given, as far as I can judge, any happy explanation of *the causes or foundation of the distinctions they have so generally adopted.*"—CULLEN.

IT was maintained by the great Hippocrates, that the vital spirit or soul, (ψυχη,) is the same in all men and in every description of animals; that as death is always produced by excessive hæmorrhage, the soul resides in the blood, with which it is diffused through all parts of the system; that all organized bodies are composed of four primitive elements, which are endowed with inherent properties of heat, cold, dryness and moisture; that all the varieties of constitution in man, whether in a state of health or disease, depend on the predominance of one or more of what he called the four cardinal humours, viz., red blood, yellow bile, black bile and phlegm; giving rise to the sanguine, choleric, melancholic and phlegmatic temperaments; that when they are duly mixed or rightly proportioned, the constitution is perfect; and that any deviation from this balanced mixture, (κρασις,) tends to produce disease. (*De Naturâ Humana,* v. vi. to ix.)

He maintained, that these four primary humours were all specifically different from each other in temperature, colour, consistence, &c.; that red blood is hot and moist; yellow bile, hot and dry; black bile, cold and dry; phlegm, cold and moist; corresponding to the nature of the different seasons in which each of them is in excess. According to this ancient theory, red blood predominates in spring, when it is often discharged from the nose spontaneously, and that it is warm and moist, because the season is so; that yellow bile superabounds during summer, when it is frequently vomited spontaneously, and, like the season, is hot and dry, therefore the cause of fevers; that black bile predominates during autumn, being cold and dry, because the season is so; and during old age, which is the autumn of life, when the blood is watery and impoverished, causing a predisposition to melancholy and sadness. Hippocrates also tells us, that phlegm is cold and moist, like the winter, when it is more abundant than at any other season; and as it is discharged from the lungs or throat during catarrh, influenza, pneumonia, phthisis, &c. he regarded it as the predisposing cause of those diseases. All this is very absurd and fanciful; for although it be true, that all diseases of the respiratory organs are more prevalent during winter than summer, and the secretion of mucus or phlegm is more copious, they are merely concomitant effects of cold. In like manner, the excess of bile and the prevalence of fevers during summer, are merely effects of an elevated temperature, impure air and other causes that arrest or diminish digestion and the formation of chyme.

In the treatise on the *Structure of Man*, yellow bile

is referred to the liver and black bile to the spleen. (Sec. i.) But in the treatise on *Human Nature*, it is said that when a man is mortally wounded by dividing the vessels of the neck, blood flows at first, very hot and very red; after which it comes mixed with phlegm, and lastly with much bile. (Sec. xi.) From which it appears, that phlegm and bile were regarded as constituents of the blood.

That the phlegm of Hippocrates was not merely the secretion termed mucus, but included the serous portion of the blood, would appear from the fact, that he describes it as the humour from which urine, sweat and dropsical effusions are derived. Whether he always meant by yellow bile the hepatic secretion, is doubtful; for although he says that it is formed in the liver, he states in another place, that on dissecting the heart of an animal he found a little *yellow bile* in the left ventricle. (*De Corde*, sec. 9.)

But that his black bile was identical with dark venous blood, is evident from the fact, that he supposed it to be generated in the spleen, which is now well known to be a reservoir of black blood. (*De Structurâ Hominis*, sec. i.) And he states that the dark grumous fluid discharged from the stomach in cases corresponding with our hæmatemesis, was black bile. (*De Morbis*, lib. ii.) Galen also says expressly that all the humours are contained in the blood. (*De Atrabile, Frob.* p. 163.) Accordingly, it was regarded by Hoffman, Morgagni, Cullen and many other distinguished moderns, as only another name for dark venous blood. Nor can there be a doubt, that in a climate like that of Greece, respiration is so far dimi-

nished by the excessive heat of summer and autumn, as greatly to impair the vital properties of the blood and change it to a darker colour than usual.

From the time of Boerhaave to that of Richerand, physiologists have described the sanguine temperament as marked by a broad chest, full and robust body, strong pulse, an abundance of rich arterial blood, a florid complexion, a cheerful flow of spirits and a vigorous exercise of all the functions, with an elevated temperature. They also represent the choleric temperament as marked by a broad chest, a high temperature, a spare but muscular frame, an active circulation, great mental power and a passion for lofty achievements; attributes which have no more connection with the size of the liver and the quantity of its secretion than with the amount of urine or of cutaneous perspiration. And if it be true that the quantity of good arterial blood is in proportion to the magnitude and soundness of the lungs, it is evident that the choleric is only a modification of the sanguine temperament. And if it be true that the intellectual endowments of men are in proportion to the magnitude of the brain, *cœteris paribus*, it must be more fully developed in such as belong to the choleric temperament, which is characterized by strong passions, aspiring ambition and great energy of mind. It is therefore obvious, that the bilious temperament is a mere phantom, which should be henceforth excluded from the forum of science and numbered with the fables of antiquity.

Again, that the melancholic and phlegmatic temperaments are modifications of the same physical con-

stitution, would appear from the fact, that they are both described as characterized by a narrow chest, a deficiency of animal heat, a feeble circulation, an impoverished state of the blood, a pallid or livid complexion and languor of all the functions: but with this difference, that the former is marked by a higher development of the nervous system, with a greater tendency to intellectual exertion, which leads to exhaustion, and predisposes to indigestion, torpor of the bowels, lowness of spirits, insanity, apoplexy, paralysis and other forms of nervous disease,—whereas the phlegmatic constitution is generally marked by a predominance of the abdominal viscera over the brain, an inanimate expression of countenance, a soft and flaccid state of the muscles, with a tendency to dropsy, diabetes, scrofula and other diseases which arise from debility.

That Lord Bacon regarded the choleric as identical with the sanguine, and the melancholy with the phlegmatic temperament, would appear from his remark, that the humours of a young man are choleric, and his blood inclined to heat,—in an old man, phlegmatic or melancholic. (*Life and Death.*) With many other modern physiologists, Dr. Cullen maintains that the sanguine and phlegmatic temperaments are characterized by light, sandy, yellow or brown hair, and fair skin; while some maintain that the choleric and melancholic are marked by dark, coarse and curly hair, with a yellowish or brown complexion. But if we except the pale, sallow and livid hues, that result from an impoverished condition of the blood, complexion has very little more connection with tempera-

ment than the colour of our garments; for when it is yellow, olive, brown or black, and the cuticle thick, the richest blood does not show itself in the skin; but when fair, the cuticle thin and transparent, it shows its character in the florid, pale or livid hue of the face. The opinion of the ancients, that yellow and dark complexions depend on the excess of yellow or black bile, was adopted by Blumenbach and Smith, who imagined that the blackness of the negro race is owing to an excess of the hepatic secretion in hot climates, whereas complexion is only skin deep, but temperament involves the whole physical and intellectual organization.

The division of temperaments into sanguine, choleric, melancholic and phlegmatic, has remained from the time of Hippocrates down to that of Dr. James Gregory, who added a fifth division, which he denominated the nervous. But another classification has been recently proposed and ably supported by Dr. F. Thomas, in a treatise entitled *Physiologie du Tempéramens*, published at Paris in 1826; in which the intelligent author refers all the varieties of constitution to the relative size of the thorax, brain and abdomen. He maintains that when the lungs are more highly developed than any of the other principal organs, the temperament is *thoracic;* that when the brain is large, compared with the chest and abdomen, it is *encephalic;* and that when the abdominal viscera are highly developed, compared with the thorax and brain, the temperament is *abdominal.*

The essential parts of this theory have been adopted by Dr. Caldwell, of Kentucky, and ingeniously carried

out, in a recent work on *Malaria and Temperament.* With a strong prejudice against the humoral doctrine,* and a singular partiality for the hypothesis of Cullen, he maintains, that as "the solids are the ruling portion of all organized matter, they must be looked to *exclusively* as the ground of temperament; that it depends, first, on diversity in the minute interior or radical structure of the tissues which compose the body; and, secondly, on difference of size and vigour in certain ruling organs of the system,"—by which he means the thorax, brain and abdomen.

But neither of these distinguished physiologists has

* Dr. Caldwell maintains, that "*humoralism* is one of the most fearful and destructive monuments of error that has ever been erected,—an idol, which, through the many centuries of its existence, has done nothing but falsify and adulterate the principles, and lamentably pervert the practice of medicine; that physicians have sacrificed millions of their fellow-beings under the fatal spell of its influence;" that *although the fluids may be vitiated in their condition, disease is not predicable of them, according to any legitimate interpretation of the word.* But the only reason he assigns for these remarkable assertions is, that "*we know nothing of the manner in which the blood is affected by different kinds of food and drink, medicines and morbid states of the atmosphere,—nor what condition of the blood predisposes to disease, and what affords security against it.*" (*On Malaria and Temperament*, pp. 124, 208, 212, 217.) With due deference to the opinions of this distinguished author, it may be asserted with confidence, that millions of our fellow-beings have been sacrificed, owing to the *ignorance of physicians in regard to the true theory of sanguification, secretion, nutrition and the manner in which the vital properties of the blood are impaired,*—and that it is high time they should set about ascertaining how it is affected by food and drink, various states of the atmosphere, medicines, passions of the mind, vicissitudes of temperature, &c.

even attempted to explain in what the diversity of organization and radical structure of the tissues consists; nor why it is that, among different nations, certain ruling organs are more fully developed than among others. The principal advantage of their new classification is, that it is simple, and appeals more directly to the senses, than that of the ancients. At the same time, it must be confessed, that, in other respects, it is imperfect and erroneous. In the first place, the thoracic temperament of Thomas and Caldwell does not differ essentially from the sanguine; for they both represent it as marked by a high temperature, great activity of all the vital functions and a full development of the muscular system, as in the Grecian statue of Hercules, and in all athletic individuals. But they have overlooked the fact, that among the natives of cold climates the chest is larger in proportion to the whole body than among the nations of the middle latitudes, or any other parts of the world, while it is well known that the polar inhabitants are diminutive in stature, and of a *feeble* or *phlegmatic constitution.* It is therefore clear, that a comparatively large chest is not always an indication of activity and great muscular power.

Nor is it true, as they maintain, that a large thorax is generally accompanied by a small brain or one of moderate size, for Plato had a large head; and it is said that he took his name from the great breadth of his chest. Dr. Caldwell also informs us, from personal observation, that General Washington had a large head; and it is notorious that he had a remarkably broad chest, Herculean frame and corresponding mus-

cular power. The celebrated Mirabeau, like Daniel O'Connell, was equally distinguished for the enormous size of his head and for the capacity of his thorax. Nor is it true, as a general rule, that a large abdomen is an indication of the phlegmatic temperament, as maintained by Thomas and Caldwell: for in Mirabeau, O'Connell, and hundreds of others that might be mentioned, it would be difficult to say whether the thoracic, the encephalic or the abdominal organs predominate. How, then, shall we determine to which temperament they belong?

Another objection to the above classification is, that it does not embrace many individuals of the choleric, melancholic and phlegmatic temperaments of the older physiologists.* It is true that, in one respect, the encephalic corresponds with the choleric constitution; for they are both represented as characterized by great energy of passion, sentiment and intellect. But it is not true, as maintained by Thomas and Caldwell, that the encephalic temperament is generally distinguished by a small or moderately-sized chest and want of energy in the vital functions. There are also many individuals who answer to the melancholy and phlegmatic temperaments, in whom all the principal or

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* Nor does it explain the manner in which temperament is modified by age; for it is certain that nearly all persons in vigorous health, during youth and the meridian of life, are sanguine and vigorous; that men are more so than women; but that during old age they become weak and phlegmatic or melancholic, even when the thorax is large, especially among such as have been intemperate, or who have over-exerted their intellectual faculties, and spent the summer of their life in excesses of any kind.

ruling organs are imperfectly and yet so equally developed, that they cannot be said to belong either to the encephalic or abdominal divisions. It is therefore manifest, that Thomas's classification does not embrace all the diversities of constitution; and that there is still room for one that is more simple and comprehensive. Moreover, if it be a fact that all the organs are formed immediately from, and vitalized by, the blood, it is manifestly an error to overlook the influence of the fluids on the development of the solids.

Again, if it be true, as I have endeavoured to demonstrate in a preceding chapter, that animal heat is the agent by which blood is formed and converted into the different tissues, it must determine the radical structure, relative size and power of all the organs, fashion every part of the body and regulate every variety of constitution or temperament,—whether we regard it as depending on the condition of the fluids, as maintained by the ancients, or on the relative size and vigour of certain ruling organs, as maintained by Thomas and Caldwell. It also follows, that as the quantity of organic particles in the blood, and the aggregate vital energy of animals, are in proportion to the capacity of their lungs and the amount of their respiration, all individuals with a broad, deep and full chest belong to the sanguine, or what I propose to call the *dynamic temperament*, whether the brain and abdomen be large or small, and whatever the complexion may be,—but that all persons with a narrow, flat or small chest, in whom respiration, sanguification and nutrition are imperfectly performed, have feeble constitutions, and belong therefore to what may be called

the *adynamic temperament*, which includes the melancholic and phlegmatic of the ancients.*

In accordance with the Grecian axiom, that "strength is derived from spirit and from blood," and depends on the amount of caloric that passes through the body in a given time, it may be observed that birds belong more emphatically to the sanguine or dynamic temperament than mammalia, and the more active among the latter, than such as have imperfect organs of respiration, and therefore fall into a state of lethargy during winter; but that all warm-blooded animals in perfect health are of a sanguine constitution, and belong to the dynamic temperament, when compared with reptiles and fishes, which are cold-blooded, imperfectly organized, deficient in strength, and therefore belong to the adynamic temperament, which includes all individuals of the human species, with small chest and diseased lungs, whether cold and dry, or cold and moist.

According to the analyses of Denis and Le Canu, the average proportion of solid particles in the blood of vigorous and healthy men during youth, adolescence

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* Should physiologists not approve of this classification, as not sufficiently descriptive, they may have a choice of the following, until something both accurate and more definite is offered. For example, when the thorax is large, the brain finely developed and well-formed, the temperament may be denominated *sanguineo-cerebral;* when the thorax and muscles predominate, it may be called *athletic*, or *sanguineo-muscular;* and *sanguineo-abdominal* when the chest and chylopoietic organs are large. But if the brain be large, the chest small or the lungs imperfect, the temperament may be regarded as *nervous;* or if the thorax, brain and muscles be small, and the abdomen predominate, it may be termed *phlegmatic*.

and middle life varies from 12·92 to 15·85 per cent., whereas in persons of feeble constitution they vary from 11 to 8 per cent. They also found that in persons labouring under phthisis, scrofula, scurvy, rickets, dropsy and other low diseases, the ratio of solid particles varied from 8 to 6·40 per cent., or nearly the same as in cold-blooded animals, in which the solid matter varies from 8 to 4·80; corresponding with the imperfect development of their lungs, brain, muscles and whole organization. Hence a common expression among the vulgar, in regard to persons whose blood is impoverished, that they are "weak as water." In persons of this class, the conversion of albumen into fibrin is imperfectly performed, owing to imperfection of the respiratory process, by which all the proximate constituents of blood are formed.

The dynamic temperament embraces the sanguine and choleric of Richerand, the thoracic of Thomas and Caldwell, with some other subordinate varieties. For example, if the chest be large, the lungs sound, the body not encumbered with fat, the health good, the muscles fully developed and the brain small, we have what has been called the *athletic* temperament, (answering to the *iron* temperament of Plato,) as in boxers, wrestlers, agricultural labourers and other individuals who have spent their lives in active employment of the muscles. In professional boxers, stonemasons and blacksmiths the muscles of the chest and arms are the most fully developed, whereas among porters, pedestrians and savage tribes those of the lower extremities predominate, because more constantly exercised. In the middle latitudes of Europe and Ame-

rica the mean circumference of the thorax, or that of the average man, does not exceed thirty-six inches; while in men of the largest size, it varies from forty-eight to fifty-two, and even fifty-eight inches, according to the best information I have been able to derive from respectable tailors in London, New York and Philadelphia.*

But if the thorax be broad, round and full, the waist small, the muscles moderately developed, the brain large, well formed and of fine texture, we have what may be called the ethereal and intellectual constitution, (answering to the golden temperament of Plato,) which comprehends the noblest specimens of the human race. It is finely portrayed in the following soliloquy of Hamlet: "What a piece of work is man! how noble in reason! how infinite in faculties! in form and moving how express and admirable! in action how like an angel! in apprehension how like a god!" The greatest poets, philosophers, orators, statesmen, inventors of arts, and heroes, of the world, have

* It is much to be regretted, that so little attention has been given by ancient and modern writers on the natural history of man, to the size and configuration of the thorax among nations and individuals, with a view of ascertaining how far they are modified by climate and modes of living. For it is of much greater importance to know the character of the chest and head than the stature of mankind; which, however, should not be omitted in our attempts to ascertain the best methods of improving the physical, intellectual and moral character of the race. But it is worthy of notice, that the circumference of the thorax is not always an exact measure of the size of the lungs; for it is *deeper or longer* in some persons than in others. The form most favourable to strength is that of fulness in front and behind, with a corresponding breadth and depth, as in men of round backs.

been formed after this beautiful and classical model, so far as we can judge from portraits, busts and the imperfect descriptions of historians and biographers. Such was the physical character of Democritus, Hippocrates, Pericles, Socrates, Plato, Zeno, Alcibiades, Alexander, Julius Cæsar, Brutus, Cassius, Cicero, Seneca and Virgil, among the ancients; and of Galileo, Bacon, Shakspeare, Luther, Melancthon, Petrarch, Tasso, Sully, Richelieu, Cromwell, Milton, Newton, Franklin, Washington, Mirabeau, Burns, Watt, Napoleon, Wellington and Byron, with many other modern heroes, sages and benefactors of mankind.

The truth is, that General Washington, the Duke of Wellington and many other illustrious men, have been even more remarkable for the capacity of their chests and for the absence of all superfluous fat, than for the magnitude of their heads. The same observation applies to Napoleon when young; for although he had a fine classical head, with a large forehead, it was less massive than that of either Bacon or Franklin. And if we can depend on the cast of him taken by Dr. Antomarchi, soon after his death, his head was very little above the average size among intellectual men; while in all the portraits of him he is represented with a deep, round and full chest. Nor is the head of Lord Brougham much, if anything, above the average size. But as it is supported by a long and large thorax, compared with the size of his spare body, he is endowed with extraordinary mental activity and the power of long-continued application,—and a spasmodic quickness of movement, which marks an excitable state of the nervous system.

Again, if the chylopoietic viscera be more highly developed than the brain, we have what Thomas calls the "abdominal temperament," which embraces that very large class of persons described by Shakspeare, with "fat ribs and lean pates." Even when the thorax is large and the body supplied with an abundance of rich arterial blood, a large proportion of it is diverted from the brain to the stomach and expended in digestion, while much of it goes to the formation of fat, which is deposited in the cellular tissue, where it hangs as a burden on the system. But here again it is worthy of notice, that the accumulation of fat indicates imperfect sanguification, owing to excessive alimentation, want of exercise, or some defect in the function of respiration. And that this state is not natural, but acquired by over-indulgence or the want of suitable exercise, would appear from the fact, that many of the lower animals when domesticated, highly fed and prevented from taking exercise, become very fat and much less active than in the wild state.

Men of the above class are generally good natured and contented while they have plenty to eat and drink; but they love repose and dislike profound thinking, or indeed any kind of exertion. It is true, that Dr. Johnson, Gibbon the historian and some other highly intellectual men, became fat and large around the waist as they advanced in age. But this was the result of over-indulgence or of sedentary habits. And I am not aware that any great hero or genius of the first magnitude has been remarkable for obesity. Compared with such men, Julius Cæsar, the spare Cassius, General Washington, the Duke of Wellington and

Lord Brougham, are what the large-chested and fine-blooded racer is to the heavy and unwieldy dray-horse. For the same reason, men of moderate stature have stronger and more active minds than such as are above the middle size. For it is impossible that a man measuring forty inches around the chest and weighing two hundred and fifty pounds could have anything like the mental energy of a man like Napoleon, whose weight, when twenty-six years of age, did not exceed one hundred and twenty-five pounds, but whose thorax was of large dimensions. Even Pope the poet had a long and capacious chest, if compared with the diminutive size of his body. Thus we perceive, that all individuals with a large thorax and sound lungs, belong to the strong or *dynamic temperament*, of which there are several varieties; such as the muscular or athletic, the intellectual or cerebral and the abdominal; which are often so combined as to form other subordinate varieties.

On the other hand, whenever the thorax is below the ordinary size or the function of respiration is imperfect, there is a deficiency of animal heat and of rich arterial blood, with a languid state of all the vital forces; constituting the weak or *adynamic temperament*, whether the muscles, brain or abdominal organs predominate. But if the nervous system be considerably more developed than the respiratory apparatus, we have that variety termed by the ancients the melancholic, which corresponds with the *nervous* temperament of Richerand and other modern physiologists. For they are both represented as marked by a small chest, a pale, sallow or livid complexion, (in-

dicating a deficiency of bright arterial blood,) a languid circulation, torpor of the stomach, bowels and of all the secretions, a spare habit, small, soft and feeble muscles, morbid sensibility, sudden fluctuations of temper, with a predisposition to nervous and spasmodic affections. And we have already seen, that the principal difference between this temperament and the phlegmatic is, that in the latter the abdominal organs are more highly developed than the brain, which is weak and lethargic.

It is therefore evident that the adynamic temperament, whether cold or dry, or cold and moist; whether denominated melancholic, nervous or phlegmatic; and whether hereditary or acquired, is rather the effect of disease than a primitive or natural constitution. And that it is often acquired, would appear from the well-known fact, that many distinguished individuals who were originally of the sanguine temperament, have been rendered melancholic or nervous by grief, anxiety, intense study, a sedentary life and repeated shocks of adversity; as exemplified in the characters of Dante, Petrarch, Tasso, Pascal, Cromwell, Newton, Voltaire, Rousseau, Zimmerman, Collins, Cowper, Burns and Byron. The misery of such men is owing to a greater activity of the nervous system than it has the physical power of supporting; or as Thomas Carlyle observes, it is "a consequence of their greatness," and the intensity of their desire to get "a deeper insight into the heart of things." (*Hero Worship.*)

That the intellectual powers of man are in proportion to the magnitude of his brain, *cæteris paribus,* especially its frontal portions, would appear obvious

from the corresponding gradations of intelligence among nations, as we ascend from the African, the Esquimaux and Samoiede of the arctic regions, the North American Indian, the Malay, the Mongolian, the Hindoo and Arab, up to the European, who has the largest forehead and the finest intellect of them all. Nor is it less certain, that among the lower animals intelligence corresponds with the size of the brain and the fulness of its anterior portions, as in many of the smaller birds, the better educated dogs, the horse, elephant and the higher orders of the monkey tribe, in which the form of the head and the degrees of intelligence are exceeded only by man.

The sensibility of any organ is also in proportion to the abundance of nervous matter with which it is supplied, *cæteris paribus*. For example, in the eagle, hawk and many other birds, the power of vision corresponds with the enormous size of the optic nerves and tubercles. The sense of smelling is likewise more acute in the common hound, in which the olfactory nerves are spread over an extensive surface, than in other dogs; while in the greyhound, whose nose is small, the sense of smell is very imperfect. The mouth and nose are larger in the African, the North American Indian and some other savages, than among civilized nations, who are inferior to them in the faculties of taste and smell.

But *why is it that many individuals with moderately-sized heads possess far greater power and activity of mind than others who have large and well-formed heads?* Until this problem is solved, human physiology, and especially that important branch of it termed phre-

nology, cannot be regarded as a complete science, even were it established that all the different organs of the brain and their specific functions had been fully discovered, which cannot yet be fairly assumed. I have already shown it to be a law of nature, that *the power of any organ is in proportion to the amount of rich arterial blood with which it is supplied, the quantity of caloric that passes through it in a given time,* cæteris paribus, *and depends on the amount of respiration.*

For example, the cohesive and contractile power of the muscular tissue is much greater in birds than in mammalia, (and greater in the latter than in reptiles and fishes,) because birds are more abundantly supplied with arterial blood, which is more rapidly distributed through their bodies. For the same reason, the structure of the human brain is firm, dense and powerful, in proportion to the rapidity with which its composition and vitality are renewed by the formative process. Hence it is, that by far the greater number of illustrious men have been distinguished no less by the capacity of the thorax than for the size and configuration of the brain. But if the chest be small, the lungs unsound, or if respiration be diminished by impure air, improper diet, intemperance, the depressing emotions, intense thinking and a sedentary life, the vital properties of the blood are impaired and the brain imperfectly nourished; so that although large and well formed, its texture is infirm or softened and its power proportionally diminished. If the skull be thick, (as in the African,) or if the carotid and vertebral arteries are small, the brain will receive proportionally less arterial blood in a given time than when

they are large; and still less when the chest is small or the lungs imperfect. All persons of this class belong to the adynamic temperament, whether the brain be large or small. And owing to the softness of its texture, the capillaries are easily ruptured, giving rise to the effusion of blood or serum, apoplexy, paralysis or idiocy. It is therefore manifest, that this is not the temperament of robust health, nor of intellectual power to the highest extent.

It is a great blessing to be born with a large thorax; for it offers the surest pledge of vigorous health and long life. Had all men such chests as the Duke of Wellington or Daniel O'Connell, disease would be greatly diminished and the duration of life augmented. I am informed that six individuals of the Wellesley family, recently alive, had arrived at the aggregate age of four hundred and forty-three years, making the average of each seventy-four years. And Mr. O'Connell stated, in a speech, that among twenty-two children of his grandmother, eleven arrived at the age of ninety-six or upwards. (Vide *Examiner*, March 14, 1841.) Like the heroes of Greece and Rome, the physical energies of these illustrious Irishmen were developed by exercise in the open air and its free circulation through their capacious lungs, without which they never could have endured so much bodily and mental exertion, nor have enjoyed such uniformly good health.

With a full chest and sound lungs, men are able to endure degrees of cold, muscular exercise, loss of sleep, excesses in eating and drinking, that would soon shorten the lives of ordinary individuals. Nor is it

true, as maintained by Thomas and other physiologists, that the thoracic or sanguineous temperament is peculiarly liable to inflammatory diseases. On the contrary, the general exemption from disease, whether of body or mind, the average duration of life, the power of enjoyment and of being useful to our fellow-beings, are in proportion to the vital energy of the system and the activity of the functions. It is equally certain that the liability to fever, inflammation and nearly all the forms of disease, are in proportion to the feebleness of the constitution; while death is merely the cessation of power and activity of the functions. And there is reason to believe, that a proper system of physical education would, in nearly all cases, prevent that imperfection of the thoracic organs which lays the foundation of phthisis, asthma, scrofula and many other diseases which become hereditary and embitter while they shorten life. The great secret of such an education is to give full scope to the instinctive love of exercise in the open air, so natural to children and all young animals. Is the chest narrow or flat in infancy? It may be greatly expanded and improved by frequent singing, reading aloud, dancing, playing at battle-door, the graces and other agreeable pastimes; or when there is sufficient strength, by fencing and other manly exercises. Are the superior and frontal portions of the brain imperfectly developed, compared with the lateral and posterior divisions? The former may be greatly improved by moderate exercise of the intellectual and moral faculties, for the same reason that the magnitude and power of any organ are augmented by action. And if the

whole brain be unduly developed in early life, it should be exercised less than the lungs and muscles.

Thus it is manifest that, to a very great extent, we can modify those unbalanced conditions of the body which predispose to disease, immorality, crime and suffering. But mankind have been so long in the habit of violating the laws of health, by intemperance in diet, the use of intoxicating liquors, poisonous drugs, too much or too little exercise, undue indulgence of the passions, unnecessary exposure to vicissitudes of temperature and bad air, that a beautiful organization and sound health are confined to a very small number, even in temperate climates, where they should be almost universal. The human mind has also been so filled with falsehoods and pernicious prejudices, from infancy up to maturity, that its native clearness in the perception of truth is greatly dimmed, and the creative power of genius is still more rare. Nor is it to be expected that men should fully obey the laws of nature and of the animal economy, until they shall be more thoroughly understood. A correct knowledge of the mean size of the thorax and brain in infancy, in both sexes, would enable us to regulate the employment of different individuals, so as to insure the best organization. But if ever mankind be destined to arrive at perfection or the full and harmonious development of all their physical, intellectual and moral powers, it must be the result of a complete knowledge of nature and its reduction to the simplicity of self-evident axioms, which may be readily understood by every one. The universal diffusion of such knowledge would enable men to see everything in its

true light and would abolish all differences of opinion. The best means would be directed to the best ends, and vice would become rare if not impossible; for a perfect system of education from infancy to maturity, operating for many generations, would produce everywhere the best organization, and the passions themselves, under the guidance of reason, would contribute no less to virtue and happiness than the higher faculties.

In regard to the influence of climate on temperament, it is maintained by Dr. Prichard, that the African negro exceeds all other races in the *firmness and density of his fabric.* (*Nat. Hist. of Man*, p. 172, first edition.) What is still more remarkable, it is maintained by Menzel, that *the choleric temperament prevails in the north, the sanguine in the south, the melancholic in the east and the phlegmatic in the west;* that the *will* predominates in the first, *sense* in the second, *feeling* in the third and *understanding* in the fourth; finally, that men belong to the choleric and phlegmatic temperaments, in which the will and the understanding predominate; but women to the sanguine and melancholic, in which sense and feeling predominate. (*German Literature*, vol. ii. p. 102.) But the thorax, brain, muscles and all the more important organs, are more highly developed in temperate climates than in either the tropical or polar latitudes,—because respiration, sanguification, secretion, nutrition and all the forces of life, are diminished by a high external temperature; and because, in excessively cold climates, animal heat is more rapidly abstracted by the surrounding atmosphere than it is obtained by respira-

tion. From which it is obvious that the sanguine or dynamic temperament, with all its complications, whether athletic or intellectual, belongs emphatically to the middle latitudes; while in the tropical and polar regions, the adynamic constitution, with all its various modifications, predominates.

The higher development of all the organs in temperate climates leads to a proportionally greater exercise of them, by which their development and power are still further augmented. So far is it from being true, as suggested by Menzel, that the sanguine temperament prevails in the south and the phlegmatic in northern Europe, that the very reverse is the fact. And we have seen that there is no foundation in nature for the existence of a choleric temperament, unless it be regarded as a modification of the sanguine with a large brain; and that the melancholic is a modification of the phlegmatic, with a predominance of the brain over the other organs, as exemplified in Dante, Petrarch, Tasso, Zimmerman, Cowper, Collins and some others; in whom it was probably induced by a want of sufficient vital energy to support the activity of the brain, aided by an undue development of cautiousness, and by the absence of hope.

As for the rest, the cerebral or intellectual temperament is more common in cities and large towns than in the country; among scientific, literary and professional men, including artists and the higher mechanics, than among servants, day-labourers, small farmers, common mechanics, soldiers, seamen, boxers and wrestlers, in whom the thorax and muscular organs are

more fully developed than the brain, because more exercised, as proved by phrenological measurements.

THEORY OF SPASMODIC DISEASES.

It was said by a writer in *Blackwood's Magazine*, that the discovery of a remedy for hydrophobia would be worthy of a great national reward, or even a title of nobility.* But are we not equally in the dark in regard to the nature and treatment of tetanus and all other spasmodic diseases? Has any one explained their proximate cause or laid down any certain principles of treatment which apply to all cases? Besides, the number of deaths from hydrophobia was only fifteen throughout England and Wales, and one hundred and twenty-four from tetanus, in the year 1839, according to the Registrar-General;† whereas it was 25,408 from all other spasmodic maladies. In a work published about fifty years ago by the celebrated Tissot of Paris, the author gives it as his opinion, that nearly all children who die under one, and even two years of age, are carried off by convulsions. (*Avis au Peuple.*)

* Alas! such is the present vicious standard of morality, even among the most civilized nations, that the man who should invent the most dreadful engine of destruction or perpetrate some thousand murders on the field of battle, would stand a much better chance of receiving a great national reward than if he were to discover an exact method of saving millions of human beings annually from disease and premature death.

† At Philadelphia, the mortality from hydrophobia was ten from January 1, 1807, to January 1, 1827, and one hundred and twenty-five from tetanus during the same period.

It was observed by Dr. Cullen, that "as we know not the condition of the brain in the ordinary conditions of the will, we are also ignorant of its preternatural state in all involuntary movements." And Mr. Morgan says, in a lecture on *Tetanus*, published in 1833, that "we can take no credit to ourselves for curing a disease respecting the proper treatment of which we positively know nothing." In accordance with the theory of Boerhaave, that "convulsions are owing to a vigorous influx of nervous influence into the muscles," Bichat referred them to a "preternatural activity of the cerebral functions."* Others maintain, with Dr. Billing, that their primary seat is in the white medullary portion of the brain; and others, with Dr. M. Hall, that they originate in the spinal marrow; while Liebig refers them to "an unequal degree of conducting power in the nerves."

But that they are in nearly all cases attended with diminished vitality of the brain, will appear from the following facts:—

1. *That, in all the higher orders of animals, convulsions are invariably produced by a great and sudden loss of blood, as when they are bled to death.* And it is generally known, that they often follow excessive hæmorrhage from the uterus after parturition. Why, then, is it that blood-letting is often practised in cases

* Some late writers erroneously maintain that strychnia, brucia, nux vomica, the upas ticuti and other narcotic poisons, *augment the irritability of the muscular fibres*, therefore should be given in cases of paralysis; but that as conia and the ticunas diminish irritability and produce paralysis, they should be given in tetanus and hydrophobia.

of tetanus, hydrophobia,* and other spasmodic diseases? Is it not more in accordance with reason and common sense to follow the maxim of Hippocrates, that diseases are to be treated by remedies of an opposite nature from that of the causes which produce

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* With a candour and magnanimity worthy of commendation, Dr. Elliottson gives it as his opinion that he hastened the death of a woman labouring under hydrophobia, by bleeding. Dr. Clutterbuck also employs it in the same disease. Yet he acknowledged before the Medical Society of London, a few years ago, that everything had hitherto failed. And he recommended that *all the Sampson remedies in the Materia Medica should be separately tried in succession.* Such is the dire uncertainty of physic, that in the treatment of diseases the most opposite remedies are thrown into the stomach, "without rhyme or reason," so that when the patient recovers it is impossible to know what one has produced the effect, or whether it was owing to the efforts of nature, in spite of a confused and empirical practice. For example, in the *Medico-Chirurgical Transactions* of 1815, there is a case of tetanus related by Dr. Phillips, brought on a young lady of delicate constitution by exhaustion from dancing and subsequent exposure to a cold atmosphere. In the first place, he had her put into the warm bath for fifteen minutes, when she became so much relieved that she begged not to be removed from it and was allowed to remain fifteen minutes longer. In the mean time he bled her, when she seemed greatly exhausted and the spasms returned, with faintness and vomiting. Yet he prescribed calomel and scammony, Epsom salts and senna. In fact, it is no uncommon thing, in cases of slight indisposition, (which nature, temperance and rest would remove in a short time,) to prescribe a dose of calomel and jalap, or scammony, salts and senna, the next morning, to carry off the mercury, &c., and then quinine to overcome the debility thus produced. So that the double task is imposed upon nature of overcoming the original disease and the morbific effects of the medicines. Alas! poor mortals! when shall ye be delivered from this sad and monstrous abuse of reason?

them? (*Contraria medentur contrariis.*) Or is it more philosophical to follow the homœopathic doctrine, that *similia curantur similibus?*

2. *But convulsions are also produced by the sudden abstraction of animal heat from the body, without any loss of blood, or when its temperature is reduced several degrees below the natural standard, as shown by the cramps induced by the exertion of swimming in cold water.* Yet the cold bath has been frequently employed as a remedy for tetanus. As might naturally be supposed, it has, in several cases, proved almost instantly fatal.

3. *It is well known that all the more active narcotic and other poisons, when taken into the stomach or absorbed into the circulation, produce convulsions and death.* Yet we are informed by Samuel Cooper, in his *First Lines of Surgery*, that solutions of opium, arsenic and even hydrocyanic acid, have been injected into the veins, with the view of curing hydrophobia. In his *Lectures on the Blood*, Magendie states, that by injecting simple water or the serum of blood into the veins of dogs, he produced difficult breathing, stupor, apoplexy of the lungs, a dissolved condition of the blood, convulsions and death; yet he informs us that he treated a case of hydrophobia by injecting two *litres* of tepid water into the veins. (*Lancet*, December, 1838.) And he observes in another place, that "so great is our ignorance of those physiological derangements called diseases, that it would perhaps be better to do nothing, and resign the complaints we are called on to treat to the resources of nature, than to act as we are frequently compelled to do, without knowing

the *why* and *wherefore* of our conduct and at the obvious risk of hastening the end of the patient." I would add, that when the attainment of certain knowledge is possible, it is an act of criminal ignorance, next to manslaughter, to practice on the lives of our fellow-beings without knowing the why and wherefore of our conduct.

4. *When the temperature of the body is reduced several degrees below the natural standard, as during the cold stage of intermittent fever, there is a constricted state of the skin, chattering of the teeth, trembling of the limbs and a spasmodic state of the whole system, as when exposed to a very cold bath.* The pulsations of the heart are exceedingly weak, and the circulation through the lungs is so far diminished, that the blood loses its florid hue even in the arterial capillaries, as shown by the livid hue of the skin. In malignant cholera, the inspirations have been so few as seven per minute, and the temperature of the blood from 10° to 25° below the normal standard, attended with a spasmodic state of the stomach, bowels and abdominal muscles, including the flexors of the extremities. In short, *whenever the temperature is reduced below the natural standard, whether by the abstraction of animal heat from the surface or by diminished respiration, owing to the influence of an impure atmosphere, the vital properties of the blood are impaired and a tendency to spasmodic action induced.* Dr. Johnson tells us, that "men die of cholera in precisely the same way as from hæmorrhage; with shrinking, paleness and coldness of all the external parts, *diminished circulation*, (the most universal and essential symptom of cholera,) and

spasms. It is therefore evident that the proximate cause is a deficient supply of animal heat and of good arterial blood.

5. *Convulsions are produced by strangulation, as in hanging or drowning, or by whatever arrests or greatly diminishes the process of respiration, whether it be exposure to the mephitic gases, the rarefied atmosphere of high mountains, a blow on the head or violent emotions of terror and other depressing passions.* The spasmodic tremour of the hands caused by intemperance in the use of ardent spirits, mercury, opium and other narcotic poisons, is owing to diminished respiration and a vitiated condition of the blood, like the subsultus tendinum of typhus and other malignant fevers, attended with a great loss of vitality and general prostration of strength.*

When the vital energy of the brain is much exhausted, every sudden impression, whether by sight, hearing or touch, causes the whole frame to start, and, in many cases, brings on repeated spasms, which, in persons of extremely shattered nerves, are induced by the shutting of a door or by the slightest current of air. At the same time, it is equally manifest, that in cases of hydrophobia and traumatic tetanus spasms are caused by the irritation of a wounded nerve, in the same way that pricking the nerve of a frog excites involuntary or spasmodic contraction of the muscles.

The convulsions of infants are far more prevalent,

* Among the *Aphorisms* of Hippocrates, he points out the danger of convulsions from cold, immoderate purging, loss of blood and from wounds. (*Aph.* i. 6, sec. v.)

and require more prompt treatment in hot climates than in the middle latitudes, and more so in the latter during summer, when the atmosphere is in a rarefied and impure state, than during winter, especially in large towns and crowded or ill-ventilated dwellings. But cold and moisture are by far the most general exciting causes of *cholera infantum* and other spasmodic diseases; to which may be added the process of teething, irritation from worms and improper diet; all of which tend to diminish the function of respiration and to prevent the due arterialization of the blood, as shown by the frequent coldness of the extremities, the pale or livid* hue of the features, loss of appetite, general debility and derangement of all the secretions. In the convulsive fits of new-born infants, the lungs should be inflated by blowing into the mouth of the patient, with the nostrils closed, and by compressing the thorax after each inflation, so as to imitate the natural process of breathing. In this way the colour of the face may be changed from purple to red, before the voluntary action of the lungs is restored.†

* In all such cases the violence of the spasms and dangerous condition of the patient are in proportion to the difficulty of respiration and the purple hue of the features, which are anxious, emaciated and shrunken. Nor is there any chance of saving life without restoring the free circulation of blood through the lungs; which can generally be accomplished by an early and judicious employment of the warm bath, frictions, diffusible stimulants and the application of dry heat, so as to maintain the temperature of the body at the natural standard. But if this point be exceeded there is danger of exhaustion.

† It was in this way that Elisha restored the son of the Shunamite from a state of suspended animation, or, as we read in

The most frequent predisposing cause of hysteria is the influence of grief, anxiety and other depressing passions, by which respiration is diminished, as shown by the difficulty of breathing, palpitation of the heart, coldness of the extremities, flatulence, nausea, constipation of the bowels, lowness of spirits, and in some cases a feeling of suffocation, attended with stupor, faintness, loss of sensibility, a spasmodic condition of the muscles about the throat, alternations of sobbing and laughter and general convulsions of the whole body. That the disease is often brought on by exposure to cold and a stoppage of perspiration, is equally evident from the copious discharges of limpid urine between the paroxysms. Some pathologists have referred the above symptoms to a congested state of the uterus and suppression of the menstrual secretion. But like all the other morbid phenomena, this last condition must be regarded as a concomitant effect of the same causes which diminish the process of respiration and impair the vital properties of the blood. Nor is it possible that any spasmodic disease can exist so long as the brain and general system are supplied with an abundance of good arterial blood, which is the fountain of life and health to all parts of the body.*

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2 Kings, from actual death. For it is said that Elisha "lay upon the child, and put his mouth upon his mouth,—when the flesh of the child waxed warm: he sneezed seven times, and then opened his eyes." (Chapter iv., verses 34, 35.)

* Dr. Marshall Hall says, that "spasm can arise *only* from irritation of some part of the spinal nervous system." How then is it that spasms are produced by loss of blood, strangulation, suffocation, hæmorrhage and the mere loss or deficient supply of animal heat; all of which are essentially negative, and therefore cannot be regarded as causes of irritation?

According to the best writers on the practice of medicine, epilepsy is brought on by loss of blood, the mephitic gases, intemperance in the use of ardent spirits, violent emotions of terror or whatever tends to diminish the power of the brain. And that the immediate cause of the frightful spasms which characterize the fit is the want of good arterial blood in the brain, is manifest from the purple or livid hue of the face, showing that, even in the arteries, the blood is black; consequently, that respiration is nearly or quite suspended during the paroxysm.

In all cases, the more suddenly the brain is deprived of good arterial blood and its power of commanding the movements of the muscles destroyed, the more violent is their spasmodic action. For it must be remembered, that as the brain receives about five times more blood in a given time than an equal weight of the body in general, its power is abolished sooner by whatever diminishes the chemical function of the lungs and the force of the circulation, than that of the muscles, which continue to contract for some time after the power of the brain has ceased, independent of its guidance, and therefore in a spasmodic or involuntary manner. The brain of infants is also much larger and receives more blood, in proportion to the size of their bodies, than that of adults; which is the reason they are more liable to spasmodic affections.

For example, in cases of decapitation the muscles contract with more or less violence until their vitality is extinguished; which proves clearly that spasms are "not owing to a vigorous influx of nervous influence into them from the brain," as supposed by Boerhaave

and other pathologists; nor to "an increased activity of the cerebral functions," as maintained by Bichat and his disciples. Nor is it less manifest, that in cases of epilepsy, (or when the process of respiration is suspended by exposure to the mephitic gases,) the power of the brain is arrested, or nearly so, while the muscles continue to contract with great force. In like manner, when respiration is greatly diminished, as in cases of cholera, the blood is sufficiently vitalized to enable the muscles to contract, although not sufficiently so to enable the brain to command their movements; which is also the case in hysteria, chorea, the convulsions of children, the spasmodic twitchings of typhus, and the mobility of nearly all individuals while in a low or very feeble state of health. If any additional proof were required that the muscles contract without any influence of the brain, it is afforded by the rigidity after death, which is a low degree of spasmodic action, therefore perfectly involuntary.

The predisposing causes of tetanus are exhaustion from over-exertion or whatever diminishes the general powers of life, such as the elevated temperature of tropical climates, where it is more frequent than in the middle latitudes, and more so in the latter during summer than winter. But all the best writers on pathology agree, that exposure to cold after exertion in the hot sun, is by far the most general cause of idiopathic tetanus. Perhaps the most simple form of the disease is that local affection termed a crick in the neck, which is always produced by cold and ought therefore to be cured by cold, according to the homœopathic doctrine of *similia curantur similibus.* It hap-

pens, however, in this, (as in many other cases,) that the most pleasant, safe and speedy method of cure is to restore that which has been lost.

Mr. Morgan relates the case of a sailor who deserted from his ship in the Thames, swam ashore, continued in his wet clothes all night and was attacked with tetanus next morning. He also states, what has been observed by many others, that "the first complaint of the patient is that he has taken cold and is suffering from sore-throat." (*Lecture on Tetanus*, 1833.)

What is called traumatic tetanus has been caused by dislocations, compound fractures, a severe burn, painful surgical operations,* such as castration, amputation of the breast, a limb, and almost every description of local injury, from a simple incision to the most serious laceration of the soft parts. Mr. Morgan knew a case produced in a scholar by the blow of a schoolmaster's cane across the back of the neck; and another by a stroke of the same instrument on the back of the hand. Baron Larrey also knew a case produced by the lodgment of a fish-bone in the fauces. And Dr. Willan relates another case that arose from intense anxiety of mind, which, like all the causes just enumerated, diminishes the voluntary power of the brain over the breathing process, and consequently, the nominal supply of animal heat. We further learn from the British and French army surgeons, that, among wounded soldiers, tetanus is rarely brought on

* Hippocrates relates the case of Scamander of Larissa, in whom tetanus was induced by a large incision, followed by the actual cautery, in a case of diseased hip-joint. (*Epidemics*, book v.)

without exposure to cold, fatigue or the depressing passions. On the 9th of January, 1839, Dr. Bird related before the Westminster Medical Society the case of a man who had chopped the nail of his thumb on one hand and injured the adjoining finger, but remained well for three days, when he was exposed to cold and wet which produced a chill, followed by fever and decided symptoms of tetanus. On the same occasion Mr. Streeter related another case that was produced by cold alone, and which, like that of Dr. Bird, was cured by the ordinary treatment employed in fever.* (*Lancet*, 1839.)

But whether the disease be idiopathic or traumatic, and whatever the remote or exciting cause may be, the prominent symptoms are essentially the same, viz., difficult and hurried respiration, cold extremities, a pale or livid hue of the surface, small and irregular pulse, loss of appetite, nausea and sometimes vomiting, constipation of the bowels, with such a derangement of all the secretions that the formation of pus is arrested in ulcerating wounds. Dr. Elliottson regards the disease as analogous to chorea, hysteria and the shaking palsy. He also observes, that in ninety-nine cases out of a hundred, tetanus in females is attended with flatulency, globus hystericus and other like symptoms.

But the most important general fact connected with

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* That all such diseases are owing chiefly to a loss or deficient supply of animal heat would appear from the fact, that *the earth itself grows rigid under the influence of winter, as if seized with approaching convulsions, like the body of man during a chill.*

the pathology of tetanus is, that in all the most malignant cases the circulation through the lungs and general system is almost wholly arrested. As an example of this, it is stated in Cooper's *First Lines of Surgery*, that when Mr. Liston amputated the arm of a patient, with a view of stopping the progress of tetanus, brought on by a wound in the thumb, scarcely any blood flowed from the divided arteries, and no ligatures were required to prevent hæmorrhage. Corresponding with this remarkable fact, we are informed by Cullen and many other distinguished writers on pathology, that during the latter stages of the disease the blood is so far dissolved as not to coagulate when drawn from the body; in which it closely resembles the blood of patients labouring under malignant cholera, which is emphatically a spasmodic disease.

In the worst forms of tetanus, the generation of animal heat by respiration is so far diminished that the temperature of the body is below the natural standard;* and the excitability is so far reduced that enormous quantities of brandy and other diffusible stimulants have been often given without producing intoxication or any perceptible increase of circulation. The system is in a condition resembling the nearly suspended animation from cold, during which the mephitic gases and narcotic poisons produce little or no

* Hippocrates observes, that "fever supervening in a case of confirmed spasm or of tetanus, removes the disease." (*Aphorism* lvii., sec. iv.) Although this aphorism must be received with some grains of allowance, it is evident that the danger of spasmodic diseases is greatly diminished by a free circulation of the blood, which generally attends the coming on of fever.

influence. For it has been observed, that during the advanced stages of tetanus the most active purgatives rarely move the bowels; and that from thirty to sixty grains of opium have been given every six hours, without producing any visible effect. Mr. Abernethy relates the case of a man who died of the disease, in whose stomach were found thirty drachms of opium which had not undergone any material change.*

From all the foregoing facts and observations it is evident, that *the proximate cause of tetanus, as of spasmodic cholera, is a torpid condition of the circulation, a dissolved state of the blood and a great loss of vitality.* Nor is it less certain, that if all the most powerful remedies in the Materia Medica were given in succession, they would be wholly unavailing, without restoring the vital properties of the blood, which can be done only by augmenting its circulation through the lungs, where it is formed and endowed with the power of carrying on all the functions. If the case be not too far advanced this object can be attained by a judicious employment of the warm bath, the application of dry heat to the surface and the use of internal

* The same torpid state of the bowels exists in the worst form of cholera, which is a spasmodic disease. Dr. John E. Cooke, then of Lexington, Ky., informs us, that in June, 1833, he gave to a patient with that disease one hundred and twenty grains of calomel, which in twelve hours produced not the slighest effect; when he gave two hundred and forty grains without any effect. After ten hours he gave one ounce, which produced a slight discharge. The same dose was repeated twice afterwards, at intervals of twelve hours, when the patient expired. (*Transylvania Journal*, Sept. 1833.)

stimulants.* In short, we must employ that agent by which the blood is perpetually formed in a state of health, enabled to excite the heart and maintain all the functions in their natural state. But the application of heat must not be continued after the body has been raised to the normal standard and the circulation restored, as it would then diminish respiration and defeat the object in view, which is to renovate the blood. When the circulation has been restored, respiration and the nutritive process may be augmented by sponging the body with cold water and by the free admission of cold air; which are important in cases of syncope and whenever there is fever. It is only, however, in the early stages and milder forms of the disease that tetanus is attended with fever; because respiration is too much diminished to produce reaction. Yet Dr. Edwards relates a case on the authority of Dr. Prevost, in which the temperature rose to 110·6°.

In regard to hydrophobia, it is still a problem whether it is propagated by a specific and contagious virus or whether it be a modification of tetanus, as supposed by Democritus and other ancients. Perhaps there is no subject on which the common sense of mankind has been more signally perverted by superstitious and

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* Since the first edition of this work was printed, I have met with several accounts of traumatic tetanus that were cured by the free use of brandy, given to the extent of three pints in twenty-four hours, and two gallons in eight days, by Dr. Wilson. Mr. Solly also had a case of tetanus which was cured by the use of stimulants, given night and day, by a careful nurse. (*Braithwait's Retrospect*, part 12.)

groundless fears than that of hydrophobia, if we except the burning of poor old women for witchcraft. Within a recent period, Magendie says it was no uncommon thing to smother patients bitten by a rabid animal between two feather beds, or to bleed them to death, with a view of speedily terminating their sufferings. And I have been told that a case of the kind recently occurred in Scotland. The prevalent opinion of medical men, that it is a strictly contagious disease, was admirably ridiculed by Baron Munchausen, who gravely tells us that "his cloak became mad while in the wardrobe, after having been torn by a rabid dog." But to be serious, if hydrophobia be generated by a specific poison, it ought to be communicated in nearly all cases of inoculation with the saliva of a rabid animal or by exposure to its bite. Yet we are informed by Mr. Youatt, that of five dogs which he inoculated with the saliva not one became rabid. And he says, in another place, that he had never been able to produce rabies by inoculation with the saliva of a dead dog, nor with the blood of a living one in the rabid state.

It was long ago related by John Hunter, that out of twenty persons who had been bitten by the same mad dog only one of them was attacked by the disease. And it was stated by Sir Benjamin Brodie, a few years since, before a Committee of the House of Commons, that out of above four thousand persons bitten by dogs suspected or actually rabid, since he had been connected with St. George's Hospital, not one, to his knowledge, had become hydrophobous. Now if canine madness were a contagious disease, like

smallpox, psora, lues or gonorrhœa, is it possible that it should have failed in more than four thousand cases? The story of Munchausen's cloak is scarcely more incredible. But Mr. Youatt thinks the contagious character of the disease has been proved by the experiments of Magendie and Breschet, who say they communicated it to a dog by inoculation with the saliva of a man who had hydrophobia. (See the *Veterinarian*, vol. iv. p. 225.) And Mr. Colman has proved that madness is often produced in dogs during hot weather by confinement, exposure to their own breath, urine and other excrements, improper food, and from too much or too little exercise. He does not, however, assert that it is never communicated by inoculation. And he believes that typhus, jail fever, the itch, the farcy and glanders in horses, the roup in fowls and the husk in pigs, are contagious maladies, often produced by impure air, filth, &c. without contagion. (*Veterinarian*, vol. iii. p. 636.)

Nor is there anything better established in the history of diseases than that hydrophobia is often produced in the human species without contagion or the bite of a rabid animal. And there is reason to believe that tetanus is often confounded with hydrophobia, if, indeed, they are not modifications of the same disease. Brodie relates a well-authenticated case, published in the *Philosophical Transactions* above a century ago, of a man who died of hydrophobia a month after he was bitten by a dog that was alive and well two weeks before his death. Dr. Watson gives an account of a man that was brought to the Middlesex Hospital on the 5th of October, 1837, who had been bitten by a dog a few

days before. His disease was apparently induced by fright, caused by reading works on hydrophobia; for he was a nervous subject. On being asked if he would have some water he became greatly excited, rushed out of his bed terrified, became furious and remained so until he died. (*Principles and Pract. of Physic*, p. 325.) Nor is it unworthy of notice, that when Dr. Webster, of Boston, was taken to the Medical College, and portions of the body of Dr. Parkman, whom he had murdered, were brought before him, he went into convulsions and called for water, at the sight of which he violently repelled those who offered it, like one writhing in the deepest agonies of hydrophobia. "The sight of water crazed him," said the reporter of the Boston *Bee*. Mr. Hutchinson also relates the case of Mrs. Sara Johnson, who had been struck on the nose by a little dog, but without causing the slightest abrasion of the skin; and who, about two weeks afterwards, (on the twentieth of November,) got wet, when she was attacked with shivering, languor, depression of spirits, thirst, furred tongue, pain in the head, back and limbs, difficulty of breathing and agitation of manner. On the twenty-third, the slightest motion of the air around her, or the sight and even mention of fluids, induced hydrophobic spasms, and she died on the twenty-fourth, after expressing a belief from the first that she would not recover. Mr. Denby gave it as his opinion that the case was owing to fright and the influence of cold.* (*Lancet*, 1839; *Trans. of the Lond. Med. Society*.)

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* I have just met with a similar case in the Philadelphia *Ledger* of September 1, 1849, reported by Dr. T. S Reid. Mr. Willets,

A still more decided case of what is termed spontaneous hydrophobia occurred in my own practice, in the year 1827. A middle-aged lady, of phlegmatic constitution, took a long walk one afternoon in the month of August, after which she sat down before an open window, exposed to a cool breeze, until she felt rather chilly. Soon after retiring to bed a sensation of stiffness about the jaws came on. On visiting her the next day, I found there was an impossibility of swallowing, and the utmost horror on the approach of liquids to her lips, owing to a spasmodic state of the muscles about the throat; which is the real cause of the dread of fluids; but seldom occurs in the disease as it exists in dogs. The pulse was exceedingly small and feeble, the extremities cold, the complexion livid and the features contracted, with an expression of extreme anxiety. Under these alarming circumstances, instead of arousing the nearly suspended circulation by the warm bath or the application of dry heat, I vainly endeavoured to administer laudanum, brandy and ether, which she could not swallow, and she expired in convulsions the following day.

Nor can there be a doubt in the mind of any dis-

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aged thirty-five, of strong constitution and active habits, returned from his labour as overseer at a ship-yard, on Tuesday evening, in his usual good health. On Wednesday morning he arose with a stiffness in the side of his neck and numbness of the arm, which he attributed to exposure to a change of temperature during the night. Not being relieved by the remedies employed, he rapidly grew worse, soon manifested all the symptoms of hydrophobia, and died on the following Friday morning, of what Drs. Condie and Reid termed spontaneous hydrophobia.

passionate medical practitioner, that in a large majority of cases in which hydrophobia follows the bite of a rabid animal, it is brought on by exposure to cold, fatigue and the depressing passions. There are also many cases on record of its being produced in persons of timid and feeble constitutions by violent emotions of terror, without the bite of a rabid animal or any local injury. The needless alarm of the community, arising chiefly from ignorance in regard to the cause of hydrophobia, is far worse than the disease, which must be treated like tetanus; for the proximate cause is the same in both.* And I venture to predict, that by an early employment of the means already suggested, they will both be found curable maladies.

In a small treatise addressed to the French Academy of Sciences in 1823, by M. Buisson, the author states, that nine days after attending a woman who died of hydrophobia, he was attacked with a stiffness about the throat, a difficulty of swallowing fluids and other symptoms of that frightful malady, which he supposed was brought on by wiping his hand (one finger of which had on it a slight sore) with a towel that had

* That the bite of a rabid animal operates in the same way as a wound which causes tetanus, and not by the introduction of a specific poison into the blood, would further appear from the fact established by Youatt and Blanc, that the virus remains inert within the wounded part until aroused into action by some irritation in such part. I have just read an account of an old man who was bitten by a maniac on the little finger, when inflammation extended up the whole arm, causing death in two days, which was attributed to the influence of "the poison communicated to his system with the bite on the finger." (See *Chambers's Journal*, No. 257.)

been employed in removing saliva from the patient's mouth. Believing himself to be attacked with a mortal disease, he resolved on stifling himself in a vapour bath, which he had raised to 107°. But, to his great surprise and delight, he soon found himself relieved from all the previous symptoms, when he left the bathing-room, dined heartily and drank more wine than usual, without any return of the complaint.

Since that time, he says that he has treated above eighty individuals who had been bitten by dogs supposed to be rabid; in four of whom the symptoms of hydrophobia had clearly declared themselves; and that in no case had he failed, except in that of one child, which died in the bath. In addition to the repeated employment of the vapour bath, he recommends the practice of inducing free perspiration, by wrapping the patient in warm flannels, covering him well with blankets or even a feather bed, and giving hot drinks; because he says, that hydrophobia is confined chiefly to animals which do not sweat, such as the dog, wolf and fox. He further declares himself so confident in regard to the success of this treatment, if adopted in the early stages of the disease, that he should have no objection to be inoculated with the saliva of a rabid animal.* Now although it must be admitted that

* We frequently hear of individuals being attacked with hydrophobia several months, and even years, after the bite of a dog supposed to be rabid. I have an account of a case, in which the symptoms did not appear for eighteen years after the bite was inflicted. But as it is now admitted by the ablest veterinarians, that the latent period of the disease, when communicated by inoculation, never exceeds twelve weeks, it is probable that all the cases

there is something romantic in the reason which Dr. Buisson assigns for going into the vapour bath, and even a doubt whether his disease was not owing more to fright than to the influence of the woman's saliva, the practice he adopted was unquestionably rational, and when early adopted is calculated to remove the proximate cause of nearly all spasmodic diseases, which I have shown to depend on torpor of the circulation and a vitiated state of the blood, owing chiefly to a loss or deficient supply of animal heat.

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which occur at longer periods after the bite are owing to some other cause, as in spontaneous hydrophobia. For it is contrary to all analogy to suppose that a poison capable of producing such fatal effects should remain latent for one or two years. The popular belief, if well founded, that individuals affected with this fearful malady bark like dogs, and even attempt to bite their attendants, must be referred to the influence of imagination and terror of the patient. When the belief in witchcraft was common, it is said that 40,000 persons suffered death in England for that offence. And it is highly probable that many cases of hydrophobia are produced, or aggravated, by the terror which arises from the belief in its contagious character, since it is scarcely known to exist in Turkey, where dogs are exceedingly numerous and suffered to run at large at all times without restraint. We are also informed by Shattuck, that only one death has occurred in Boston from hydrophobia in thirty-five years.

CHAPTER VI.

THEORY OF FEVER.

"I have always thought it a greater happiness to discover a certain method of curing the slightest disease, than to accumulate the largest fortune."—SYDENHAM.

BUT how is it possible to arrive at a certain method of curing even the slightest disease, without knowing the cause of vital action during health, which consists in the natural, unimpeded and pleasurable exercise of all the functions? And if it be true, that "no genuine physiological principle has ever yet been discovered," how is it possible that pathologists should explain the phenomena of disease, which literally implies pain or the absence of ease, and is always the result of some departure from the natural state of the functions? The truth is, that all diseases must be referred to some derangement of the organizing principle, the natural operation of which constitutes health. And such is the simplicity which pervades the infinitely diversified operations of nature, that a complete knowledge of any one disease would afford a key by which to unfold the rationale of all the rest.

For example, it may be laid down as an axiom, that *fever or inflammation, whether general or local, is an essential condition of all diseases, except in those cases in which the reaction is not sufficient to induce a preterna-*

tural temperature; as in syncope, apoplexy, the worst forms of cholera, cold plague, tetanus, hydrophobia and other spasmodic affections. Yet the most enlightened authors of the present day admit, that the theory of fever is wholly unknown;* consequently, that the various methods of treating it are empirical, vacillating, inefficient and often injurious. Dr. Fordyce observes, that "it is a disease, the appearances of which have been in no way accounted for."

It may also be received as a fundamental principle

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* Dr. James Johnson observes, in his work on *Tropical Climates*, that the proximate cause of fever and other forms of disease is totally beyond our comprehension; and Dr. Alison regards it as "unreasonable to expect that we shall *ever* go far in explaining the peculiar phenomena of fever." (*Outlines of Physiology and Pathology*, p. 513.) He further observes, in another work, that "the adaptation of arterial blood to the maintenance of vital action in general and of circulation in particular, seems to be one of the primary laws or conditions of vitality, for which it is in vain to look for an explanation." (*Cycl. of Pract. Med.*, part xxiv.) And Dr. Edwards observes, when treating of febrile heat: "The circumstances are too complicated to admit of our deriving conclusions from them." (*Influence of Physical Agents*, part iv. c. 10.) Like all the American writers on the subject, Dr. Chapman says: "We may expect to know nothing of the essential nature of fever or of the intimate changes in the organization which constitute it." (*Compend. of Practice.*) Dr. George Gregory also observes, that "if we cannot unfold the nature of the healthy vital actions, it is not surprising that pathologists have failed in explaining those which occur in disease." (*Theory and Pract. of Physic*, p. 164.) He seems fully aware that all the phenomena of disease are immediately connected with some derangement of the nutritive process. But he adds, "the whole subject of the functions of the capillary system is exceedingly obscure; and that Bichat considered it altogether beyond our reach."

in pathology, that *every variety of constitutional disease is ushered in with a loss or deficient supply of animal heat.* But we are informed by Dr. Southwood Smith, in his work on *Fever*, that physiologists know so little about the mode in which animal heat is generated, that they have given no satisfactory explanation of its diminution or increase during disease. In accordance with the views of Hoffman and Cullen,* he maintains that the chill and all the following symptoms are clearly referable to some derangement of the brain and spinal cord; that the cold stage is produced by a disturbance of the respiratory and circulatory

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* The celebrated theory of Cullen, as summed up by the author in his *Practice of Physic*, was, that "the remote causes of fever are certain sedative powers applied to the nervous system, which, diminishing the energy of the brain, thereby produce debility in the whole of the functions, and particularly in the action of the extreme vessels; but such, however, is, at the same time, the nature of the animal economy, that this debility proves an indirect stimulus to the sanguiferous system; whence, by the intervening cold stage and spasm connected with it, the action of the heart and large arteries is increased, and continues so till it has had the effect of restoring the energy of the brain, of extending this energy to the extreme vessels, of restoring therefore their action, and thereby especially overcoming the spasm affecting them; upon the removing of which the excretion of sweat and other marks of relaxation of the excretories take place." But he never explained how the remote causes induce debility, spasm and the cold stage; nor in what way the latter induces the hot stage. And, what is still more difficult to comprehend, he represents both the hot and cold stages as efforts of the *vis medicatrix naturæ* to obviate the effects of morbific agents. (See sections xlvi. lii.) The truth is, that although Cullen speaks of his theory as "a generalization of facts, from a cautious and full induction," it is now very justly regarded as a mere tissue of gratuitous assumptions, which explain nothing.

organs, which no longer receive their accustomed supply of influence from the nervous system; while the hot stage is owing to some morbid action of the pulmonary and systemic capillaries. (*Pages* 81–84, 345.)

In a recent work on the *Practice of Medicine*, by Bright and Addison, the authors maintain that the primary seat of fever is the ganglionic system of nerves. Yet they observe, that "as we are ignorant of the nature and operation by which heat is evolved during health, we cannot offer any satisfactory explanation of the cause of its increase in fever and inflammation, unless indeed we may *suppose it to depend upon the more increased activity of the circulation*, which is manifestly present in the recent form of the disease." (*Page* 123.) And Dr. Tweedie repeats, "we know so little about the cause of the generation of animal heat, that no satisfactory explanation of its increase or diminution has been given." (*Cyclop. of Pract. Medicine*, part viii. p. 158.)

It has been long received as an axiom in medicine: *Remove the cause and the effect will cease.* But if all diseases depend on some departure from the natural state of the functions, and therefore a derangement of the vital forces, it follows that a knowledge of the cause of these forces is absolutely essential to a right theory of pathology and therapeutics. Nor is it enough to know that diseases depend on an altered condition of the blood, without knowing the causes of its circulation, formation, renovation and derangement. *If we would merit the title of physicians, we must know how the various forms of disease originate, and the reason why remedies produce their effects.*

I have already proved in the foregoing chapters of this work, that all the remote or predisposing and exciting causes of disease tend to reduce the temperature of the body; that respiration is diminished by exposure to the high temperature of hot climates and seasons, impure air, imperfect nourishment, the depressing passions, intense study, narcotic and other poisons, loss of blood or excessive evacuations of any kind, concussion of the brain, compound fractures or whatever tends to lessen the voluntary command of the nervous system over the chemical function of the lungs; that when the vital heat of the body is abstracted by exposure to cold and moisture, or expended by muscular exertion faster than it is obtained by respiration, the same general effect is produced.*

Pathologists have usually reduced the causes of dis-

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* By far the most general exciting cause of fever, even in hot climates and malarious situations, is exposure to cold and moisture, after the body has been weakened by the predisposing causes. And it may be asserted with confidence, that in nineteen cases out of twenty, the chill might be prevented by due attention to warm clothing, aided by a light but nutritious diet and by keeping up a fire at night to expel dampness. Grant Thorburn states, in his *Autobiography*, that during the yellow fever in New York, he never saw a single case of the disease which was not brought on by exposure to rain, cold night air without sufficient clothing, fatigue, intemperance or some other obvious and avoidable cause that was overlooked by the Faculty, who seemed to regard only the vitiated state of the atmosphere. Many interesting cases which he relates in detail, and the judicious comments upon them, render his chapter on the subject highly important in a practical point of view. He says that whenever the epidemic made its appearance he put on his winter clothing; and that although constantly employed in attendance on the sick he enjoyed uninterrupted health.

ease to three classes, which they have termed the *remote, exciting* and *proximate.* But the principal difference between the two first classes is, that the one precedes the other in the order of time; while the proximate cause is the result of their action, and implies that immediate condition of the body in which the disease consists, or what has been called *ipse morbus.* It has been often asserted by modern authors, that no one symptom is always present at the beginning of fever, and without which the disease could not exist. But so far is this from being true, that if we except those cases in which some noxious agent has been suddenly introduced into the blood, *there never was a general fever without a previous reduction of temperature, which is the first prominent link in the chain of morbid phenomena, and the invariable cause of all the following symptoms.* In accordance with this view, it was maintained by Hippocrates, that fever is uniformly ushered in with coldness or a loss of spirit, by which the humours are thickened and determined to the internal parts of the body.* (*De Flatibus*, sec.

* However diversified the remote and exciting causes of disease may be, they all operate in the same way, modified, however, by their intensity or duration and by the constitution of the patient. Some of them, as the narcotic and other poisons, not only diminish respiration, but disorganize the fibrin and red particles, or combine with and precipitate the albumen of the blood. That exposure to bad air also produces a morbid state of the blood long before the symptoms of disease are actually developed, would appear from some experiments of Dr. Potter, who found, during the prevalence of yellow fever in Baltimore, that the blood of individuals who lived in the infected parts of the city (although from every outward appearance and inward feeling they were in perfect health) resem-

iv., vii.) So far, his pathology was more clear than that of the moderns, who have repeated times without number, that "during the cold stage, from causes unknown to us, the blood leaves the surface and becomes engorged in the viscera." But as Hippocrates knew not how animal heat is obtained by respiration and transferred to the solids in combination with arterial blood during health, it is not surprising that he should have given no explanation of the manner in which the various predisposing and exciting causes bring on the cold stage, nor how the latter produces the subsequent fever, the essence of which he vaguely enough defined to be, "the excess of heat, mixed up with noxious qualities." When the body was cold and the excretions were arrested, he employed the warm bath; but cold affusions and even iced water, when the fever was on; which was good practice. It was the opinion of Pythagoras, Plato and many other Greek philosophers, that all evil in nature consists simply in deficiency or excess, and that what is rightly proportioned or self-balanced alone is good; a doctrine which certainly applies to the phenomena of health and disease.

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bled that of persons labouring under the worst forms of the epidemic; the serous portion on separating was of a yellowish or orange hue, and strikingly different from that of persons residing in the pure air of the country. He further states, that hundreds who escaped any formal attack of the fever, complained at times of nausea, giddiness, headache, constipation, general languor, with pains in the back and limbs; showing that the disease existed in a latent state and required only some exciting cause, such as exposure to cold, fatigue or intemperance, to bring it into full action. And it is notorious, that the inhabitants of malarious districts are generally pale or sallow, indicating an impoverished state of the blood.

That respiration is diminished during the chill that ushers in the various forms of fever, pneumonia, bronchitis, influenza and every other species of constitutional disease, would appear from some experiments of Jurine, who found that less carbonic acid was generated during the cold stage and after blood-letting, than during health. And it was found by Nysten that the same effect was produced by an obstructed or congested state of the lungs. The consequence of which is, that during the cold stage of ordinary fever, the temperature under the tongue is reduced from three to six degrees below the normal standard; while in those malignant intermittents termed algid, it sometimes falls fifteen or twenty degrees below the healthy average, as in the worst cases of epidemic cholera, in which respiration is so far diminished that reaction seldom takes place, unless by the timely employment of the warm bath or the application of dry heat.

But as it is a law of nature that the force and frequency of the heart's action, *cœteris paribus*, are always in proportion to the temperature of the blood, they are diminished during the cold stage, as shown by the slow and feeble or irregular state of the pulse; which is attended with shuddering and a spasmodic condition of the whole body. Moreover, as the blood is formed and renovated in the lungs by respiration, it follows that whenever this important function is diminished, the vital properties of the blood must be impaired, no less certainly than by the chemical influence of the narcotic and other poisons. For example, when the function of the lungs is wholly arrested, as in cases of drowning, hanging or confinement in the mephitic

gases, all the arterial blood in the body of a healthy man is changed to the venous state, and its power of carrying on the operations of life destroyed in about ninety seconds; the reason of which is, that it is no longer renovated by giving off carbon and hydrogen, nor by receiving its accustomed supply of vital heat. And as the temperature of the body is reduced below the natural standard during the cold stage of fever, the blood is not depurated, as in health, by the elimination of sweat, urine and other excretions, which, being retained, must still further derange its vital properties. If at this stage of the disease blood be drawn from a vein or even from the temporal artery, it is found to be unusually dark coloured, as might naturally be inferred from the livid hue of the surface, especially in cases of great depression, during which it is sometimes difficult to obtain a flow of blood, owing to its extreme viscidity.

If, then, it be true, that animal heat is the agent by which blood is formed, converted into the different organs, and maintains them in a state of healthy activity, it is evident that whatever tends to diminish the supply of this important principle must impair the healthy properties of the blood and thus lay the foundation of disease. The essential symptoms are the same in every variety of fever, whether brought on by the abstraction of caloric from the influence of cold and moisture, its expenditure by over-exertion, or by the various causes which diminish respiration. But as they are most distinctly marked in the intermittent form of the disease, I shall proceed to show that all the morbid phenomena which characterize that type

may be traced to a reduction of temperature and a vitiated condition of the blood, which cannot retain its healthy properties unless constantly circulated through the lungs, where it is formed, vitalized and prepared to nourish the tissues.

In the first place, that the shuddering or spasmodic condition of the whole body, is not the proximate cause of ague, as maintained by Hoffman and Cullen, but a secondary effect arising from the loss or deficient supply of animal heat, is evident from the fact, that the same spasmodic condition is induced by immersion in the cold bath and by exposure to the fumes of carbonic acid. Nor is it less certain, that the small and feeble pulse which marks the cold stage is induced by whatever diminishes the temperature of the blood, the circulation of which through the lungs being impeded, causes anxious and difficult respiration. The surface is pallid or livid, because the blood is imperfectly arterialized; while the features are shrunken and the extremities diminished in bulk, because they are not duly supplied with blood, which accumulates in the central organs. The bowels are torpid, perspiration is checked, and there is a deficiency of the urinary secretion, which is pale or colourless. And as the blood is no longer depurated by the excretion of those compounds that pass off through the emunctories during health, it becomes still further vitiated. For example, as about six pounds of matter are discharged every twenty-four hours from the lungs, skin, kidneys and bowels, it is manifest that whenever this superflous matter is retained for only a short time in the blood, its vital properties must be proportionally de-

ranged. What then must be its condition after all or the greater part of the excretions have been locked up for several days, as in most cases of fever?

In the mean time, as the brain and nervous system are no longer supplied with good arterial blood, there is a loss of sensibility, impaired memory, confusion of thought, headache and stupor, which, in some cases, approaches the condition of apoplexy. Again, that the loss of appetite, nausea and sometimes vomiting, which attend the cold stage, are owing to a deficiency of good arterial blood in the capillaries of the stomach, is evident from the fact, that the very same symptoms are produced by excessive loss of blood, the influence of intense cold, the inhalation of mephitic gases or the rarefied air of high mountains, emetics, the narcotic and other poisons or whatever tends to debilitate that important organ, arrest the secretion of gastric juice and with it the process of digestion. The consequence of which is, that no chyme is formed during the cold stage of fever to unite with bile, which accumulates in the gall-bladder and duodenum, until discharged by vomiting or in the form of bilious stools. It is therefore obvious that the proximate cause of fever is not an excess of bile, as maintained for the last two thousand years; nor debility of the brain and a spasmodic state of the extreme vessels, as supposed by Cullen; nor inflammation of the stomach and bowels, as supposed by Broussais; but that the primary cause of these and all the other symptoms is a loss or deficient supply of all the animating principle, diminished circulation and a consequent vitiated state of the blood; to which may be traced the universal debility of the

brain, stomach, bowels, voluntary muscles, and the general feeling of soreness, with an aching in the back and limbs. Such are the cardinal symptoms that mark the cold stage of intermittents, which are invariably ushered in with diminished respiration, circulation, sanguification, secretion, nutrition and of all the vital forces.

Dr. Hodgkin refers the cold stage to diminished power of the heart and of the circulation in the systemic capillaries, while he attributes the preternatural temperature both to acceleration of the circulation occasioned by the heart's reaction, and to the universal suspension of sensible and insensible perspiration, by which, during health, the excess of animal heat produced is rapidly carried off. (*Pages* 493–5.) But he confounds cause and effect, in his explanation of the cold and hot stage, the first of which is owing to a direct loss of caloric or to a diminished supply of it by respiration, causing a diminished activity of the circulation, which is again augmented by the preternatural temperature. He thinks that the solution of the fever which marks the sweating stage may be accounted for quite as well by supposing a mere return to the ordinary state of the functions, as by the gratuitous assumption of the generation of some *materies morbi* during the two first stages, and their subsequent rejection during the sweating stage. (*Page* 497.) He admits that his theory does not afford any explanation of the curious and interesting phenomena of periodicity and crisis. (*Page* 505.) He observes, that "in some healthy and in not a few morbid actions, we see that a new product, whether fluid or solid, is very much influenced by the cha-

racter of the surrounding parts; that in the condensed cellular membrane, in the neighbourhood of bone, it sometimes happens that masses of bony matter are deposited, but are perfectly detached; and that the numerous instances which we see of ossification at the origins or insertions of muscles are probably referable to the same cause." Again, "the natural structures in the neighbourhood of malignant tumours are apt to degenerate into a substance in some respects resembling that of the original tumour." (*Pages* 532–3.) He speaks of nutrition as resulting from the combined action of the vascular and nervous systems. (*Page* 534.) That farina or starch may be converted into gum, and both into sugar; and these into various acids, alcohol, ether, &c., though some of the possible links may not be always essential. (*Page* 537.)

In the second volume of his *Lectures on Morbid Anatomy*, Dr. Thomas Hodgkin has offered some views on the nature of fever, which may be regarded as a slight approximation to the truth. He observes: "Fever, I imagine to depend on the suspension or at least very considerable interruption of that process by which, during health, the various parts of the system are continually undergoing a change; the old materials being removed, while others are substituted in their place." And he adds: "Of the exact mode in which these changes take place, and of the causes which affect them, we are, and probably shall long continue to be, to a great degree ignorant." (*Page* 490.) That the process of nutrition is interrupted in fever, has been always admitted by medical authors. But it is manifestly not true, that the process of disintegration

by which *the old materials are removed*, instead of being interrupted during fever, is augmented; as proved by the rapid emaciation which takes place.

But as the process of breathing, although much impeded, is still carried on during the cold stage; and as very little of the heat thus obtained is employed in combining the blood with the solids and in maintaining the various secretions, it gradually accumulates, until the temperature under the tongue rises to 104° and sometimes to 107°, according to the observations of Currie, Fordyce, Elliottson and Müller, to 109° in those of Cheyne, and even to 111° and 112° in cases of high inflammatory fever, according to M. Coupil.*

* According to the observations of Dr. A. Donné, recorded in the *Archives Générales de Médecine* for July, 1835, the temperature and pulse in various diseases were as follows:—

	Temperature.		Pulsations.	
Puerperal fever	102·	to 104·	152	to 166
Typhus fever	101·30	104·	84	136
Inflammatory fever	96·40	104·	60	102
Rheumatism	98·30	101·75	76	96
Enteritis	100·20	101·58	76	104
Phthisis	96·	103·10	68	120
Pleurisy	94·38	102·10	80	106
Pneumonia	96·40	103·	92	126
Hypertrophy of the heart	94·40	103·10	64	150
Chlorosis	99·	101·75	72	104
Jaundice	96·40	98·30	36	62
Hemiplegia	99·72			124
Hysteria	98·	99·72	76	102
Diabetes	96·40	97·25	78	84

But this table requires to be greatly extended, so as to embrace all the various forms of disease, during the cold and hot stages. In the *Lancet* of August 29, 1835, some experiments of Becquerel and Breschet are recorded, representing the temperature of patients labouring under various diseases at the *Hôtel-Dieu*, the

The immediate consequence of which is, that the action of the heart becomes more frequent and vigorous, by which the blood is propelled with increased force into all parts of the body, and the general torpor that existed during the cold stage is gradually removed.

Moreover, it is worthy of special notice, that as a larger amount of blood is sent through the lungs, more carbon and hydrogen are given off to unite with atmospheric oxygen; so that more caloric is obtained by respiration during the hot stage and imparted to the blood, than even during health, as proved by the experiments of Jurine, Nysten and more recently by those of Mr. MacGregor, who found that during the climax of scarlet fever, measles and smallpox, from 20 to 50 per cent. more carbonic acid was exhaled from the lungs of patients in the Glasgow Infirmary than in a state of health.* And it is a striking

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results of which correspond with the above, so far as they go. In a scrofulous child during the febrile state, the thermometer in the mouth (it should always be under the tongue) stood at 98·50°; while in an inflamed tumour it rose to 104°. They also found the temperature of a hemiplegic man 98·88° on the diseased side, and 98·07° on the sound side.

* There are many facts, however, which prove that the increased high temperature of the body in fever is not always owing to augmented respiration. It has been already shown, that in the healthy state of the system respiration may be increased four-fold, by exercise, without causing any considerable rise of temperature under the tongue. There is also a case related in the *British and Foreign Medical Review* for July, 1839, p. 198, of a man in St. George's Hospital, suffering from injury of the spinal column, whose temperature was 111°, while his inspirations were only five or six per minute. Nor is it less certain, that in many cases of pulmonary congestion, such as mark the progress of winter typhus

coincidence, that the pulsations of the heart are augmented in about the same ratio during the hot stage, the tendency of which is to improve the vital properties of the blood, by increasing the chemical function of the lungs in which it is formed and renovated, as shown by the bright and florid hue which it assumes, the redness it imparts to the skin and its increased power of coagulating when drawn from the body, compared with its dark, grumous and vitiated state during the cold stage.

But as it is some time before the nutritive properties of the blood are restored, even after respiration is re-established, the caloric thus obtained is imperfectly transferred to the solids; so that there is often a feeling of chilliness, while the patient feels preternaturally warm to another person, until the full development of the hot stage, attended with general debility and a dull pain in the head, back and limbs, not unlike that which is produced by the immediate influence of external cold; but with this difference, that in the former case it is more permanent and difficult to remove, because owing to a radical derangement in the vital properties of the blood.

The consequences of which are, that the secretions

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and pneumonia, the generation of carbonic acid is greatly diminished where the temperature is above the natural standard. Respiration is also much diminished in phthisis, owing to the accumulation of tubercles in the lungs, and subsequently to an extensive loss of their substance. In consumption, the blood often exhibits a somewhat milky or oily appearance, owing to the manner in which the process of sanguification is impaired by ulceration of the lungs, in which chyle is converted into blood.

remain for some time suspended, as shown by the clammy state of the mouth, furred tongue, dry skin and thirst. The urine is also scanty and high-coloured during the hot stage, but contains a larger proportion of uric acid, the urates of ammonia, of soda or of lime, and extractive matters. Yet it must be observed, that whatever amount of animal heat may be obtained by respiration, it is incapable of performing its healthy vital office of nourishing the tissues, and is therefore employed in converting the albumen of the blood into fibrin, which is always augmented during the preternatural temperature of fever and inflammation, but diminished in asthenic diseases. Nor is it more strange that a diminished transfer of heat from the blood to the solids should induce general debility, torpor of the stomach, bowels and liver, pains in the head, back and limbs, than that exposure to a March wind or sitting for some time in a cold room, should cause an aching, stiffness and numbness of the extremities, or that a rapid expenditure of animal heat by over-exertion should cause a general soreness and stiffness of the muscles.

But in ordinary cases of intermittent fever, the natural tendency of the hot stage is to limit its own duration and put an end to the paroxysm. This it does by augmenting the action of the heart and the quantity of respiration, by which the vital properties of the blood are improved and sent freely into all parts of the body; when the previous torpor of the brain, stomach, intestines and voluntary muscles, is succeeded by an increased activity of all the functions. The effete matter of the system that had accumulated

in and still further vitiated the blood during the cold stage, together with the superflous amount of caloric that marks the hot stage, are carried off through those natural sewers, the skin, kidneys and bowels, when the sweating stage comes on and puts an end to the paroxysm. Such are the leading symptoms that mark the progress of intermittent fever, which may be regarded as the type of all the other varieties.

But why do the paroxysms return at nearly regular periods of twenty-four, forty-eight and seventy-two hours, as in the quotidian, tertian and quartan forms of fever? Why is the cold stage longer, while the paroxysm is shorter, in the quartan than in the tertian, in which the cold stage is again longer and the paroxysm shorter, than in the quotidian? Why is the chill shorter and less distinctly marked in fevers that continue, with slight remissions in the morning, for several days or even weeks, than in intermittents? Why, in nearly all of them, should it come on more frequently in the early part of the day than after noon? And why, in continued fevers, does the remission occur in the morning? So far as I am aware, none of these important questions have ever yet been answered in a satisfactory and philosophical manner by pathologists.

The reason why the paroxysms of intermittent fever return at nearly regular intervals of time, must obviously be sought in those general laws of periodicity which mark the revolutions of the animal economy in health, under the influence of season, changes of temperature, day and night, sleeping and waking; all of which modify the various functions in a regular and

uniform manner. The annual leafing and flowering of trees and plants are governed by thermal influence. All the phenomena of nature are subject to periodicity, from the revolutions of planets to those of the atmosphere and of the ocean, the birth, growth and decay of organized bodies. And, as there are certain periods of the year most favourable to each class of diseases, so are there certain periods of the day when the forces of life are at a minimum and the system most liable to the invasion of fever, modified by circumstances which are often overlooked. This tendency to periodicity is strikingly exemplified in many of our artificial habits, which have been termed "second nature." For instance, if an individual accustom himself to remain awake until three o'clock in the morning for several weeks or months and to rise at ten, it will be some time before he can go to sleep at an earlier hour, although he may rise at seven in the morning; and so of many other acquired habits, all of which, however, are subordinate to the revolutions of nature.

In accordance with the general theory of the ancients, that fever is owing to a redundancy of bile, it was maintained by Hippocrates, that the tertian, quotidian and continued forms of the disease are determined by different quantities or degrees of vitiation of the biliary secretion; and that quartans are owing to an excess or viscid state of what he called black bile.* (*De Naturâ Hominis*, v. vi. xxviii.)

* He further maintained, that fever is an effort of nature to expel morbific matter from the body by vomiting, purging, sweating, diuresis, spontaneous hæmorrhage, cutaneous eruptions, tumours and abscesses; or to render it harmless by a species of assimilation,

In the treatise on *Prognosis*, Hippocrates observes, that the most malignant class of fevers terminate in death on or before the fourth day; another class of less malignity end on the seventh day; a third class on the eleventh; a fourth on the fourteenth; a fifth extends to the seventeeth; and the sixth to the twentieth day; that all acute diseases terminate in from four to twenty days, with intervals of about four days. But in his treatise on *Critical Days*, he observes, that some fevers terminate on the thirtieth day, and others on the fortieth; while some extend to sixty days, beyond which the diurnal character is lost. In the same

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termed by him concoction. And as the paroxysms of intermittent fever return at stated intervals, he supposed that a certain definite period is required to bring about what he called the crisis, whether favourable or not. But there is reason to believe, from his own statements, that it is only the milder forms of the disease in which the tendency of nature to observe stated periods can be distinctly traced; and that even in these they are often interrupted by maltreatment or by the operation of some violent exciting cause. For example, it was observed by that great man that in one hundred and sixty-three cases of fever, one hundred and seven terminated on one or other of the following days, the *third*, *fifth*, *seventh*, *ninth*, *eleventh*, *fourteenth*, *seventeenth* and *twentieth;* that none occurred on the second nor thirteenth, and by far the greatest number on the seventh, fourteenth and twentieth; that of the favourable terminations, less than a tenth happened on non-critical days; whereas above a third of those which were fatal occurred on the non-critical days; showing even in continued fevers a tendency to periodicity, which, however, seems to be interrupted in cases of extreme malignity. After all, I am inclined to the opinion of Asclepiades and Celsus, that Hippocrates was led by the Pythagorean doctrine of numbers to overrate the importance of critical days.

treatise, the twenty-first day is said to be critical, instead of the twentieth, as stated in the *Prognostics.*

But it was contended by Cullen, that "the causes of the protraction of paroxysms, and therefore of the continued form of fevers, are, that the remote causes operate by occasioning either a *phlogistic diathesis or a weaker reaction.*" (*Practice of Physic,* sec. lxv.) And he tells us, that "the phlogistic diathesis consists in an increased tone of the whole arterial system." From which it would follow, according to this theory, that the continued form of fever depends either on increased action or diminished reaction. Besides, if the phlogistic diathesis mean anything, it is merely a *feverish disposition,* and is the very thing which required explanation. In opposition to the opinion of nearly all the most enlightened physicians from Hippocrates down to Sydenham, that fever depends on a vitiated state of the fluids, it was further maintained by Cullen, that it often arises from cold, the depressing emotions and mechanical injuries, without the introduction of any morbific matter into the blood; consequently, that it is not owing to changes in the state of the fluids, but depends chiefly on some cause acting on the nervous system or primary moving powers of the animal economy, and thus producing a spasmodic state of the extreme vessels. But I have shown that whatever tends to diminish the functions by which the blood is formed and depurated, must very soon derange its healthy properties, whether it be cold, the depressing passions, concussion of the brain, an impoverished diet or impure air.

That all the varieties of fever are modifications of the

*same disease and arise from different degrees in the intensity or duration of the causes which produce them, has been already suggested in a preceding chapter of this volume,** and will further appear from the following general facts:—

1. That both quartans and tertians change into quotidians, and the latter into the continued form of fever, which assumes the typhoid or inflammatory type, according to the constitution of the patient and the more or less depressing tendency of the predisposing causes, as remarked by Sydenham, Morton and many other physicians of Europe and America.

2. That in cases of intermittent fever, the hot stage

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* I have shown that diseases of the respiratory organs predominate in the higher latitudes, especially during the colder months; but that the various forms of fever, cholera, dysentery, diarrhœa and hepatitis, prevail to the greatest extent in hot climates and seasons, owing to the operation of an high temperature and a vitiated state of the atmosphere, both of which diminish the supply of heat by respiration. It is therefore evident, that the first class is owing to a *loss*, and the second to a *deficient supply* of the animating principle. The most remarkable difference between them is, that in the former the loss of heat is generally local, superficial or of short duration; so that if soon restored by artificial warmth, a speedy recovery may be expected; whereas in diseases brought on by excessive heat and impure air, the vital properties of the blood are more seriously impaired, than by the sudden or partial abstraction of caloric. But if from exposure to external cold, the function of respiration be permanently diminished, as in pneumonia, bronchitis, laryngitis or pleurisy, the vital properties of the blood are impaired in the same manner and often to the same extent, as if produced by malaria or any other morbific agent. In short, however various the remote and exciting causes may be, the essential symptoms are the same in all diseases and are owing to a loss or deficient supply of the animating principle.

is always protracted longer than usual, before passing into the type of more frequent repetition or the continued form.

3. That there is a gradation in the malignity of fever and debility of the patient, from the quartan, which is the mildest of the intermittents and therefore has the longest interval, to the most deadly forms of typhus, yellow fever and plague.

4. That in temperate climates, intermittents prevail when the predisposing and exciting cause are less intense; remittent when they are more malign; and after the powers of life have been exhausted by long exposure to impure air of a high temperature, they become merged in the continued form of fever.

5. That the most malignant varieties of continued fever are still more prevalent in tropical and warm climates, where the predisposing causes are more intense and constant in their operation; but

6. That in all climates and seasons very fatal forms of continued fever are generated by constant exposure to the concentrated malaria of crowded dwellings, poor-houses, hospitals, prisons and other ill-ventilated dwellings; or from concussion of the brain, compound fractures, lacerations and other violent injuries; all of which tend to diminish respiration, impair the vital properties of the blood, and bring on a chill.

7. And lastly, that the causes of intermittents operate with less intensity or for shorter periods of time, than when they produce the continued form of the disease, is demonstrated by the fact, that in the former the paroxysm runs its course in *five*, *ten* and *fifteen*

hours, on an average, after which there is a complete intermission of all the symptoms.

But I have already shown, that all the predisposing and exciting causes of disease tend to produce a vitiated condition of the blood. Nor is it possible that any serious and permanent deviation from health can exist so long as every part of the body is supplied with a sufficiency of good arterial blood. And that the different forms of fever depend on the extent to which the vital properties of the blood are impaired, would appear from the following facts:—

1. That the paroxysm is shorter and the interval longer, in quartans than in tertians, in which, again, the paroxysm is shorter and the intermission longer, than in quotidians; whereas the continued form of the disease lasts for many days or weeks, with slight remissions.

2. That in all the milder forms of fever the blood exhibits nearly the same phenomena when drawn from the body as during health, except that it coagulates more slowly, and therefore usually presents a buffy coat, or what has been called the inflammatory crust.

3. That in typhus, yellow fever, plague and all the forms of malignant continued fever, (as in blue cholera, tetanus, hydrophobia and the latter stages of pneumonia,) the blood is so far altered from its natural state, that it requires from thirty minutes to an hour or longer to coagulate in a very imperfect manner; while in the worst cases it exhibits either a preternaturally viscid or a dissolved and putrescent state.

4. That the blood of individuals exposed to a pes-

tilential atmosphere is found to be in an highly diseased condition before any formal attack of fever, as proved by the experiments of Dr. Potter before cited, and by those of Dr. Stevens, in the marshy districts of New York.

But it still remains a problem, *why the duration of the cold stage is inversely as that of the hot?* This question has been the gordian knot of pathology for above two thousand years. For the purpose of placing the subject in as clear a light as possible, I shall proceed to show that catarrh, which may be regarded as the mildest form of fever, the chill or stage of depression, is longer than in the quartan, and diminishes in duration through the tertian and quotidian, until we arrive at the continued form of the disease.

In the first place, then, if an individual in previous good health be exposed for some time to a cold wind, damp night air, a shower of rain, or a draft of air while sitting in a cold room, the temperature of his body is gradually reduced below the natural standard; by which more or less of a chill is produced, the action of the heart diminished, perspiration checked, the various secretions somewhat deranged and the vital properties of the blood to a certain extend impaired. But as the nutritive properties of the blood and its power of maintaining the secretions are diminished in a very slight degree, it is often from twelve to twenty-four or even thirty-six hours, before there is any perceptible fever, which goes off in a very short time after the circulation and activity of the emunctories have been restored, by which the blood is depurated; and does not return again without a repetition of the

exciting cause, for the obvious reason that the blood has returned to its natural state.

But if an individual be exposed for some time to malaria of sufficient intensity to impair the vital properties of the blood in a mitigated degree, and then to a shower of rain or some other exciting cause calculated to bring on a chill, the latter continues for a longer or shorter period, according as the vital properties of the blood have been previously more or less deranged, which depends on the duration or intensity of the predisposing causes. When these have been moderate, the cold stage lasts for one or two hours, because the vital heat obtained by respiration continues to unite the blood with the solids for some time after the chill has commenced; yet as the blood becomes sufficiently deranged during the stage of depression, to arrest or greatly diminish the nutritive process, whatever amount of heat is not transferred to the solids accumulates and brings on the hot stage, which continues until the blood is restored to its former state, when there is a complete intermission of all the symptoms. But if the patient remain exposed to the predisposing cause of the disease, the paroxysm returns at stated intervals of one, two or three days, unless prevented by the use of bark and other tonics, or by employing the hot bath two or three hours before the period of the cold stage. And as the vital properties of the blood are less impaired in quartans than in tertians, the paroxysm is shorter, while the intermission is longer in the former than in the latter. For the same reasons, the cold stage is longer in tertians than in quotidians, and longer in the latter than in the con-

tinued form of fever; while the paroxysms become longer and the intermissions shorter, until the latter wholly disappear.

But when individuals have been exposed for a considerable time to the concentrated malaria of pestilential districts, crowded and ill-ventilated dwellings, poor-houses, transport ships or prisons, the vital properties of the blood are so far impaired, that almost immediately after the commencement of the cold stage, and often before it is completely formed, the fever comes on. And as it is impossible that it should cease before the nutritive properties of the blood are restored, it continues with only slight remissions till the termination of the disease or the death of the patient. When the exciting cause is extremely virulent, as in the Black Hole of Calcutta, the blood is so far vitiated in the course of a few hours or perhaps even a shorter time, that the chill is so quickly followed by fever as to be scarcely perceptible. When the streams of life have been thus vitiated, many days or weeks are required to bring about their restoration to a healthy state; and when the blood has been once thoroughly disorganized, the physician can do little more than palliate the most urgent symptoms, which generally followed by death.

Thus it is evident, that there is a progressive deterioration of the blood, from the mildest catarrh and quartan ague, to the most malignant forms of synochus, typhus, yellow fever and plague. But why does the chill that ushers in the fevers arising from pneumonia, concussion of the brain, compound fractures and other serious injuries, often remain from sixteen

to thirty-six hours? And why does the fever assume the continued form?

The most probable reason is, that before the injury was received the blood was in a healthy state; so that, although respiration is sufficiently diminished to cause a reduction of temperature, weak pulse and cold extremities, it is some time before the nutritive process is sufficiently arrested to produce fever. But as the vital properties of the blood are necessarily impaired to a considerable extent during the stage of depression, it cannot be restored to its former state for several days, during which time the fever continues without any intermission and assumes the typhoid or inflammatory type, according to the constitution of the patient and the extent of the injury. It must, however, be observed, that if, before receiving the injury, the patient has been exposed to some of the other predisposing causes of fever, it follows the cold stage much sooner and is proportionally more difficult to resolve, because the blood is in a more vitiated state. Nor can it ever be restored to a healthy condition otherwise than by promoting its free circulation through the lungs, where it is formed, and the evacuation of whatever is superfluous or injurious from the skin, kidneys and bowels.

It still remains to inquire why the cold stage of fever comes on generally in the forenoon, or far more frequently than in the afternoon; and why in the continued form of the disease, there is a morning remission?

The solution of these queries will be found in the fact, that respiration is always very much diminished

during sleep, and arrives at the minimum about midnight, when all the energies of life are proportionally reduced; so that as the coldest part of the twenty-four hours is just before sunrise, if the body be not well covered or its temperature maintained by artificial warmth, the chill comes on at an early hour or some time before mid-day. In accordance with this fact, it has been observed, that in a large majority of cases the attack of epidemic cholera was during the night or early in the morning. In his letters on *Cholera*, as it appeared in New York, Dr. Payne says, that as remarked in other countries, the attack commenced in the night toward the approach of day, and in the morning. (*Page* 84.)

If the healthy properties of the blood are not entirely restored after the first paroxysm, (which is seldom the case,) or if the patient be still exposed to the primary cause of the disease, it is repeated about the same time of day, at intervals of twenty-four, forty-eight or seventy-two hours, according to the intensity of the remote cause, the degree of exposure, constitution of the individual, &c. And as the preternatural temperature of continued fever is always diminished for a time, if not permanently, by cold ablutions, so does it abate during the coldest part of the twenty-four hours, as in the morning remission, which is promoted by the stillness and darkness of the night and repose of the patient, who is still more relieved if he obtain a little sleep, however imperfect it may be.

The predisposing and exciting causes of apoplexy and paralysis are generally the same as those which produce fever; with this exception, that in the former

they operate more immediately on the brain.* For example, it was long ago observed by Dr. Heberden, that apoplexy is far more prevalent during either excessively hot or cold weather than at any other time, *cœteris paribus.* At New York, where the extremes of temperature are greater than in Europe, the mortality during the severe winter of 1795 exceeded that of the following mild winter in the ratio of fifty-two to thirty-one; and it is proportionally greater during the hottest part of summer than in spring, autumn or even a mild winter. We have also seen from the

* According to the best writers on pathology, the predisposing and exciting causes of apoplexy and paralysis are, whatever tends to diminish the energy of the brain; such as the depressing emotions of grief and anxiety, intense and long-continued study, intemperance in the use of fermented liquors, the fumes of lead, the long use of mercury, exposure to fatigue, impure air, excessive loss of blood, disease of the heart, congestion of the lungs and abdominal viscera, the narcotic poisons and concussion of the brain; all of which diminish respiration, impair the vital properties of the blood and weaken its circulation through the brain. It is also worthy of special notice, that the symptoms of apoplexy correspond very nearly with those which mark the cold stage of cholera and the more malignant forms of intermittent fever, which are ushered in with the same congested state of the brain, viscid condition of the blood, coma and loss of sensibility. The numbness of ague must also be regarded as a mitigated and temporary species of paralysis, which is often brought on by exposure to cold alone. That apoplexy is owing to congestion of the brain and not to an increased flow of blood to that organ, is evident from the experiments of John Hunter, who found on opening the temporal artery during a fit, that the blood was dark and viscid, as in cases of obstructed respiration from exposure to the mephitic gases, immersion under water or strangulation; but gradually changed to a bright hue as respiration became more free.

recent *Reports* of the Registrar-General, as digested by Mr. Farr, that the mortality from apoplexy and paralysis has been from 30 to 50 per cent. greater in London during winter than summer, which is always comparatively mild in Great Britain, where typhus fever is also more prevalent and fatal during winter than any other season. This is more especially the case in Ireland, where, owing to the want of suitable nourishment and clothing among the poor, about one-fourth of the whole mortality is caused by typhus, which in nearly all cases is brought on by the immediate influence of cold, according to Dr. MacCormack. And that the most malignant typhoid fever is generated by the influence of cold, without malaria, is sufficiently attested by the records of medicine; especially in the United States, where, about thirty years ago, an exceedingly fatal disease, termed cold plague or pneumonia typhoides, prevailed throughout the western country and some parts of New England, during the middle and latter parts of winter.* It is

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* The most prominent symptom of the disease, as in the more malignant forms of typhus in Europe, was a congestion of the lungs and abdominal viscera, with a dissolved condition of the blood. In all such cases, the obvious indication is to persist in the employment of fomentations, the warm bath or the application of dry heat, together with warm cordials, until the action of the heart and circulation through the lungs are roused, the vital properties of the blood improved and the secretions restored. The same observations apply equally to cholera, tetanus, hydrophobia and other spasmodic diseases; all of which are prototyped in the cold stage of fever. In the *Medical Gazette* of July, 1837, there is an account of spotted fever, attended with a livid hue of the skin and the same viscid or dark and grumous state of the blood as in ma-

not sufficiently understood by the community, that daily or frequent exposure to cold alone, until the general circulation is enfeebled and respiration diminished, (as shown by the coldness of the extremities and blueness of the surface, in persons thinly clad,) is one of the most common predisposing and exciting causes of low and protracted fevers. For I have already shown, that when the powers of life have been greatly reduced by impure air, the excessive heat of summer and that of tropical climates, exposure to cool nights, damp foggy mornings, a shower of rain or getting the feet wet, is the ordinary exciting cause of fever. It was truly observed by Cullen, that the conditions which favour the operation of cold are general debility, fasting, evacuations, fatigue, loss of sleep, the depressing emotions and previous disease.

What is termed *coup de soleil* is only a milder form of apoplexy, brought on by over-exertion under the influence of a burning sun, when the surrounding temperature is above that of the blood; by which respiration is so far diminished and the power of the circulation reduced, that the brain is no longer duly vitalized and the patient falls down in a state of apoplexy or prolonged syncope, until aroused by sprinkling water in the face or by cooling ablutions, which

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lignant cholera. After finding (says Dr. Wilson, of Middlesex Hospital,) that the ordinary treatment failed, the warm bath, with cold applications to the head and a saline mixture composed of thirty grains carbonate of soda, twenty grains chloride of sodium and six grains chlorate of potassa were employed, when seventeen out of nineteen cases recovered; whether owing to the stimulating influence of the warm bath or to the saline mixture, must be left to the decision of the intelligent medical reader.

tend to augment respiration, together with the nutritive process. On the other hand, when the powers of life have been reduced by age and other predisposing causes of debility, the capillaries of the lungs are paralyzed by cold, respiration and the power of the heart diminished, by which cerebral atony and congestion are induced, followed by apoplexy, paralysis or some other dangerous malady.

It was the opinion of Hippocrates, that coma and apoplexy are owing to a *frigidity and thickness of the humours in the brain; consequently, that they should be rarefied by heat, applied in the form of fomentations.* Nor can there be a doubt, that the proximate cause of syncope,* coma, catalepsy, epilepsy, apoplexy and the low delirium of typhus, is a deficient supply of good arterial blood and vital heat to the brain. Morgagni, De Huën and other authors, relate cases of apoplexy

* It is sometimes difficult to distinguish apoplexy from syncope, as the following case will exemplify. A clerical gentleman who had been for some time accustomed to close mental application, delivered a sermon on Sunday morning and immediately afterwards attended a funeral, by which he was much exhausted. He then took a hearty dinner and commenced the afternoon service, during which he fell backwards in the desk, in a state of syncope, from which he slowly recovered. Now if this gentleman had been fifty years of age or older, or if his brain had been weakened still more by previous habits of intemperance, the case would have been one of decided apoplexy, which is often brought on by a hearty meal. This operates in a twofold manner: first, by pressing upon the ascending vena cava, thus preventing the free passage of blood into the right side of the heart and thence into the lungs; or by diverting a portion of the blood which usually circulates through the brain to the stomach, for the purpose of carrying on the process of digestion.

in which the blood as it flowed from the veins was actually cold. (*Payne's Med. and Physiolog. Comment.* vol. ii. 31.) But under the erroneous impression that most of these morbid conditions are owing to an increased flow of blood to the brain, many practitioners resort to bleeding, which often increases the debility of the cerebral capillaries and thus causes effusion; an effect which is also frequently produced in other parts of the body by the loss of blood, without tending in the slightest degree to remove the proximate cause of the congestion. But in all cases of apoplexy and concussion of the brain, the powers of life are reduced below par and require the use of remedies adapted to arouse the nearly suspended circulation; such as hot brandy, wine or some other stimulating cordial, hot applications, alternated with cold affusions and fresh air, with a view of augmenting respiration.

It was again observed by Hippocrates, that "*nature is the chief physician in disease;* that untaught and unlearned, she knows and does what is best." (*Epidem.* book vi. sec. 6.) But it is worthy of special notice, that by *nature* he meant the principle which animates the universe and performs all the operations of the living body.* He also maintained that the whole art of medicine consists in knowing how and when to re-

* Aristotle represents nature (φυσις) as the moving principle and the soul of animals, in which it was the cause of nourishment and growth. (*De Part. Animalium.*) Like Hippocrates, Plato also calls nature (φυσις) the principle of motion or a producing cause, consisting of a vivifying Fire, which Aristotle called the fifth element, and most of the ancients Heaven, the Ether, the soul of the universe, &c.

move what is superfluous and to add what is deficient; or, in the version of Vanderlinden: "Medicina nihil aliud est nisi adpositio et ablatio—ablatio quidem eorum quæ excedunt—adpositio vero eorum quæ deficiunt." (*De Flatibus*, sec. iii. *et Omnia Opera Hippocratis.*)

Bacon also observes, that "man, while operating, can only apply or withdraw natural bodies; while nature internally performs the rest." (*Novum Organum.*)

Again, says Godfrey Herder: "in what does the art of the physician consist, but in acting as the servant of nature and hastening to the aid of the multifariously working powers of our organization?" Nor can there be a rational doubt, that the highest wisdom of the physician is to follow the indications of nature in the prevention and treatment of disease. But how can he do this without knowing the cause of all the vital functions and the mode in which it maintains them in health? How can he restore the different organs to their natural state without knowing what is best calculated to augment, diminish and thus modify all their actions?

Although but vaguely understood, the fundamental doctrine of the ancients in regard to the curative powers of nature, has been adopted by a large majority of modern pathologists; and especially by the illustrious Sydenham, who maintained that fever is an effort of nature to correct or expel morbific matter from the blood, by vomiting, purging, sweating, diuresis, spontaneous hæmorrhage or some other evacuation; that the plague is a complication of actions to throw

out some offending matter through the emunctories or by the formation of buboes and other eruptions; while gout is a contrivance of nature to purify the blood and purge the recesses of the body. Nor is it unworthy of notice, that the *Archeus* of Paracelsus and Van Helmont, the *animal spirits* of the later mechanical and chemical physicians, the *anima* of Stahl, the *nervous fluid* of Willis, Hoffman, Baglivi, Boerhaave, Barthez and Cullen, were only different names for what Hippocrates termed ἀρχη, πνευμα and φυσις. But as they never identified their polyonimous agent with any known principle, it is not surprising that none of their theories have been found capable of explaining the vital functions in either health or disease. Yet such is the force of truth, that men who have no definite idea of what the word φυσις means, still speak of it as the executive agent in creation. For, when they say that *nature* performs so many operations in the mineral, vegetable and animal world, they virtually recognize the doctrine of the ancients, who regarded it as the formative principle that governs all the actions of the living body.

Without the assistance of nature the physician could perform no cures, any more than the farmer could raise corn and grass without the heating power of the sun. But this doctrine was carried to a vicious and dangerous extent by many of the older practitioners, who were in the habit of treating fever by hot applications, to the exclusion of fresh air, cooling drinks and ablutions. Even at the present day, it is maintained by Parry and some other pathologists, that not only fever and inflammation, but coma, convul-

sions, apoplexy, epilepsy, paralysis, chorea, dropsy, dysentery, diarrhœa and the formation of tubercles, are efforts of nature to counteract the influence of some morbific agent.

So far is this from being true, that all diseases are attended with a diminution of the *vis medicatrix naturæ*, which, as I have already shown, is merely another name for the aggregate of the actions of the organizing principle by which blood is formed, purified and prepared to maintain the functions in their natural state. Whenever the free circulation of blood through the lungs and general system is greatly diminished, as it always is by a serious loss or a deficient supply of caloric, the *vis medicatrix naturæ* can no more perform its office of restoring the functions to their natural state, than plants can flourish and grow when the circulation of their sap is arrested by the frost of winter. When there is congestion of the lungs, stomach and bowels, brain or any other important organ, the *vis medicatrix* can effect little or nothing toward restoring the patient to health, until the obstruction is overcome and a free circulation is re-established throughout the system, which can be achieved only by the vital principle. The essential condition of fever and inflammation is a derangement of the nutritive process, and of all those actions by which the healthy powers of life are sustained. At the same time, it must be admitted, that the tendency of the hot stage is to augment the action of the heart and the circulation through all parts of the body, by which the previous torpor of the cold fit is overcome and the sweating or secreting stage brought on, as in the various grades of intermittent fever.

It must also be admitted, that emetics and purgatives induce a spasmodic action of the stomach and bowels, by which the offending agents are removed; but it is by weakening the parts on which they operate and thus diminishing the power of nature, that they produce these effects, which also follow an excessive loss of blood and the employment of the cold bath when carried too far. It cannot therefore be said with reason, that the nausea, vomiting and convulsions thus induced, are salutary efforts of nature to counteract the operation of morbific causes which are purely negative. Nor is it true, that the effusions which take place during inflammation, dropsy and apoplexy, the profuse discharges from the bowels in dysentery and diarrhœa, or the spasms of cholera, tetanus and hydrophobia, exert the slightest tendency to remove the proximate cause of these symptoms, which owe their existence to debility and a diminution of those actions that constitute the *vis medicatrix naturæ*.

On the erroneous supposition that diseases arise from an effort of nature to expel some morbific agent from the blood, the *Hydropathists* cause their deluded patients to remain exposed to the cold bath from one to two or three hours daily, until fever is induced or the body is covered with eruptions and ulcers; which are evidently produced by the influence of cold and must be cured by overcoming the weakened condition of the capillaries, as in all cases of congestion and inflammation.*

* It is a curious fact, that we are indebted to an ignorant empiric for the elucidation of a most important principle in pathology; viz. that cold alone, or the abstraction of caloric from the body by

The cold water system has been recently tested by Albert, a well-informed physician in Austria, who states that individuals subjected to the hydropathic

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the continued employment of the cold bath, cold wet bandages, and by drinking enormous quantities of cold water, is capable of producing a vitiated condition of the blood, dryness and roughness of the skin, herpes, boils, ulcers, abscesses, violent headache, dizziness, tremor of the limbs, (a species of palsy,) nausea, vomiting, diarrhœa and fever; all of which are regarded as salutary efforts of nature to expel morbific matter from the blood. (See *Claridge on Hydropathy*, pp. 122, 196, 214, 239.) And yet the practice is now extensively employed for the cure of nearly all diseases, including inflammation of the lungs, rheumatism and gout. Claridge says expressly, that few individuals pass more than five or six weeks under the treatment of the cold water system, *without being charged with eruptions and boils;* that Priessnitz causes his patients to drink cold water until *sickness* or *diarrhœa* is produced; which proves, he observes, that "the stomach contains the remains of diseases which the water has disturbed; consequently, that it is requisite to drink more," as Dr. Sangrado would say. (*Page* 109, first edition.) Verily, this barbarous system has been appropriately termed *Hydropathy*, which literally means the *water disease*, instead of the water cure. That the recoveries at Graefenberg, (which have been shamefully exaggerated,) have been owing chiefly to good air, exercise, friction, sweating and *leaving off the cold water treatment after a few weeks*, would appear from the statement of Claridge, that when fever is produced or extensive suppuration takes place, "the baths are suspended during the discharge of these humours; by which the system is much benefited." (*Page* 118.) And that it would be rapidly destructive of life in old people, very young children and all individuals of feeble constitution, is still more certain. It was stated the other day, in a report by a teacher in one of the London poor-houses, that *during cold weather the children were cut down like skittles*, on leaving the windows of the school-room open for the admission of fresh air. The only patients I have seen, who had made a full trial of hydropathy, were an aged gentleman in delicate health, who while rapidly sink-

treatment for two or three months, are apt to acquire a habit of body not dissimilar to that of scurvy. The pulse becomes feeble, soft and accelerated. The patient is subject to palpitations and a continual feeling of lassitude, which are followed by a spongy state of the gums, with apthous ulcerations of the interior of the lips and cheeks. From which this judicious observer concludes, that *an immoderate use of cold water has a tendency to impoverish the blood.* (*Bulletin of Med. Sci.*, vol. iv. p. 83.)

Moreover, that cold is a very general predisposing

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ing under the treatment, expatiated on its many virtues till the last day of his life; and a middle aged gentleman, in whom it produced a permanently sore leg, which he seemed to regard as a decisive proof of its salutary influence in carrying off bad humours. Since the first edition of this work was published, I have read a judicious treatise on *Hydropathy*, by Dr. Rausse, who frankly admits that the followers of Priessnitz have erred in their excessive use of water and at too low a temperature. But the practice of remaining for hours, every day, in a sitting bath at 64°, (and from half an hour to an hour in water at 40°,) drinking from ten to twenty or thirty glasses of cold water, is so extremely painful to endure, and is so completely at war with the natural instinct of self-preservation, that it is not likely to become general, nor continue long, except among fanatics, who in all ages have been the willing victims of self-torture. It must, however, be admitted, that when patients do survive this treatment, their general vigour is augmented. For I have proved that a rapid loss of caloric, whether caused by exposure to cold or by over-exertion, is attended with a proportionally rapid waste of the solids, and creates the necessity for a large amount of food to supply the waste and support the process of respiration, which, like sanguification, secretion and nutrition, is so far augmented as to produce a rapid renewal of the whole body, as during the period of growth in young animals and convalescence after emaciation from illness. (See *pages* 713, 881, 941.)

and exciting cause of scrofula, scurvy, erysipelas, scarlatina, measles, smallpox and all other eruptive diseases, whether specifically contagious or not, would appear from the late *Reports* of Major Tulloch, on the diseases and mortality of the British troops in various parts of the world; according to which eruptive disorders are comparatively rare in tropical and warm climates. So that, notwithstanding nosologists have described several hundred specific maladies, exclusive of varieties and combinations, it is highly probable that they are all modifications of one and the same disease, diversified by climate, season, the nature, intensity or duration of the causes which produce it, by varieties of constitution, by age, sex, diet, exercise, state of the mind, rest, sleep, &c. Such, in fact, was the opinion of Hippocrates, who maintained that the essence of all diseases is one and the same, but modified in their forms by diversity of location. (*De Flatibus.*)

This much is absolutely certain, that all the cardinal symptoms of every constitutional fever may be traced to a loss or deficient supply of the animating principle and to a vitiated state of the blood. For I have demonstrated that so long as the blood is in a condition to combine with the solids and maintain the various secretions, there can be no preternatural temperature of the body; because the vital heat is transferred to the several tissues and expended in preserving their activity as fast as it is obtained by respiration; and that all constitutional diseases are invariably attended with more or less fever, except when respiration is too far diminished to produce reaction, as in cholera, cold

plague, the worst forms of typhus, tetanus, hydrophobia and other low diseases.

So long as there is a free circulation of good arterial blood through the lungs, pleuræ, trachea, larynx and Schneiderian membrane, there can be no phthisis, pneumonia, pleurisy, croup, laryngitis, influenza, nor even the slightest catarrh. So long as the abdominal viscera are supplied with an abundance of rich arterial blood, there can be no torpor of the stomach, bowels and liver; no loss of appetite, dyspepsia, cardialgia, colic, gastritis, hepatitis, dysentery, diarrhœa, constipation, nor any serious derangement of the chylopoietic organs. So long as the brain and nerves are freely supplied with rich arterial blood, there can be no stupor, delirium, headache, apoplexy, hemiplegia, local paralysis, neuralgia, loss of sensibility, nor any important disorder of the sensorial functions; if we except monomania, which, in an endless variety of ways, has been supposed by some to afflict a large proportion of the human race, including poets, many distinguished philosophers and founders of systems. At the same time, I am inclined to believe with Hippocrates, that nothing contributes more to a sound state of mind than good blood. "Opinor autem inter omnia quæ in corpore sunt, nihil magis ad prudentiam conferre quam sanguinam." (*De Flatibus*, sec. xx.) There is a real foundation in reason for the importance attached to good blood, in a moral and intellectual as well as a merely physical point of view. The want of it begets ill temper and selfishness in persons who at other times are amiable and benevolent. It was judiciously observed by Hippocrates, in his treatise on

Regimen in Acute Diseases, that "the species of maladies would be almost innumerable if every symptom experienced by the patients were held to constitute a disease and receive a different name." Galen also condemns the Candian physicians, who split diseases into endless varieties, instead of attending to the essential nature of each.

But all the predisposing and exciting causes of disease tend to dimish the process of respiration by which the blood is generated, and that of the emunctories by which it is depurated, until it is no longer in a condition to nourish the brain, nerves, muscles and other tissues, when a very slight exposure to fatigue, cold or some other exciting cause, brings on a chill, stagnation of blood in the lungs, torpor of the skin, kidneys, bowels, and a retention of nearly all the effete matter of the body in the blood, which is thus still further vitiated. The manner in which the blood is depurated by the various excretions and vitiated by their retention, may be strikingly illustrated by the sanatory police of London. For example, the sewers of that immense city perform the same office in carrying off its excrementitious matter as do the skin, kidneys and bowels, which are the natural sewers of the living body. If the supply of fresh water were cut off and the excretory ducts of London were obstructed for a few months or even weeks, it would be very soon visited by the plague or some fatal epidemic, as in former times, when suffered to remain in a filthy state.

I have already shown, that the hot commences sooner after the first symptom of the cold stage, and

continues for a longer time in proportion to the previous vitiation of the blood; that when the latter is slight the cold stage remains from one to two hours or longer and the paroxysm about five hours, after which there is an intermission of all the symptoms, excepting slight debility, until the fourth day, as in quartans; that when the predisposing causes have been of greater intensity and the vital properties of the blood have been still more impaired, the fever comes on sooner after the chill, (which is thus shortened,) and continues for about ten hours on an average, or until the nutritive properties of the blood are sufficiently restored to bring on the sweating stage, when there follows an intermission that continues until the third day, as in tertians; that when the predisposing causes have been of still greater intensity and the blood has been proportionally vitiated, the fever comes on sooner again after the chill, (which is still further shortened,) and continues about fifteen or sixteen hours, as in quotidians; after which there is a brief intermission until the next day; and lastly, that when from exposure to causes of greater intensity, the sanguineous fluid has been still further changed from its natural state, the chill is scarcely formed before the vital heat obtained by respiration ceases to combine with the solids and accumulates so as to produce the preternatural temperature of fever, which continues without any intermission till the termination of the disease.

I have moreover shown, that the debility and general malignity of the fever increases from the quartan (which very seldom if ever proves fatal, except from improper treatment) to the quotidian, which

often passes into the continued type. Were it not that in all cases of fever the blood has been previously altered from its natural state, it might be cut short at once by employing the hot bath an hour or two before the expected chill, which would thus be prevented. It also follows, that as the blood is always deteriorated during the chill and improved by the augmented action of the lungs during the hot stage, it must be a matter of primary importance to follow the indication of nature, and prevent the recurrence of the cold stage by means of the warm bath or a suitable application of dry heat. And it is highly probable, that all the milder forms of fever would be thus arrested very soon; while those of the continued type would be proportionally mitigated and shortened in their duration; for by this practice we should strike at the very root or proximate cause of the disease, instead of prescribing at random for this or that symptom.

Much labour has been expended within the last few years in post-mortem examinations, with a hope of discovering the primary seat of fever. But although a certain amount of valuable information has been thus acquired, we might as well seek for the cause of hurricanes in the desolation they produce, as for the rationale of fever in local irritation, congestion or inflammation, without ascertaining "*the first link in the chain of diseased effects.*"

The primary seat of fever is not the brain, spinal marrow, ganglionic nerves, the solar plexus, (which has been recently represented as the centre of vitality,) the stomach and bowels, Peyer's glands, nor in any particular organ, but in all parts of the body, and espe-

cially in the blood, which is the life of the solids, (as maintained by Moses, Hippocrates, Servetus and Harvey,) the alpha and omega of health. The physician who is ignorant of this, has yet to learn the grammar or first elements of the great science which he professes.

The whole theory of medicine must be founded on a knowledge of the mode in which the animating principle operates in health, and of all the physical agents that diminish, augment or in any way modify the functions of respiration, sanguification, secretion, nutrition, sensation and muscular motion. I would therefore repeat what was said in a previous chapter, that *if anything deserves the name of universal remedy, it is the principle of life itself, which converts food into blood, fashions every part of the body as if by a divine intelligence, renews its composition when wasted by illness, heals wounds, ulcers and abscesses, expels whatever is superfluous or injurious, connects all the organs into one harmonious system and maintains it in a state of health.* The celebrated *vis medicatrix naturæ* is only another name for the operations of the vital principle; a perfect knowledge of which would give to mankind a more effectual and certain method of curing or rather of preventing disease, than all the drugs of the Materia Medica, which would be reduced to a very small compass; for we have seen that many of the *heroic* remedies, as they are called, impair the vital properties of the blood and operate as morbific agents.

It may be received as an axiom, that so long as respiration is properly maintained by pure air, nutritious aliment and a cheerful state of mind, while the

temperature of the body is kept at the natural standard by avoiding damp night air, showers of rain, wet feet, chilling winds, cold rooms, over-exertion, intemperance, &c. there could be no serious aberration from the healthy state. But men have yet to learn that all their vital functions are more or less modified by every change of their temperature, and the latter by everything which operates upon them, whether for good or evil; that "a single excess blurs and confuses the music written on our minds; that an untimely vigil weakens and bewilders the delicate minister to our inner temple." (WILLIS.)

To remove the causes of disease when practicable, and to assist nature when unable to relieve herself, is the province of the enlightened physician, whose title is derived from the word φυσις, and implies that he is the priest or servant of nature, without which he can perform no cures. The salutary agency of heat is implied in the words *health* and *healing*, which may be traced to *Helios*, signifying the sun among the Greeks, Phœnicians, Egyptians, Hindoos and ancient Celtic nations. Apollo, who was the god of medicine, was also a mythological personation of the sun, which is manifestly the fountain of life, and therefore of health, throughout creation. Nor is it unworthy of notice, that the name of Æsculapius (who is represented as the son of Apollo and founder of the healing art in Egypt) was derived from three oriental words, *Es, kul* and *ab*, meaning *heat, the universal parent* or generator of life and preserver of health. An ancient prophecy of his life and actions is beautifully described by Ovid, in the following lines translated by Addison:—

"Hail, great physician of the world! * *
* * * * who, in years to come,
Shall heal the nations and defraud the tomb!
Swift be thy growth, thy triumphs unconfined,
Make kingdoms thicker and increase mankind."
(*Met.* book ii. l. 640.)

We owe it to the bounty of Providence, that whatever is most conducive to permanently agreeable sensations is most favourable to health. In temperate climates, summer and autumn are the most *delightful* seasons of the year and the most *healthy*. But as they are disagreeably hot within the tropics, they are unfavourable to health and long life, while winter is pleasant and salubrious. There is nothing more *delightful* to the mind than hope, friendship, love and the consciousness of well-doing, nor anything more conducive to *health* and *longevity;* whereas there is nothing more surely inimical to both than the *painful* emotions of fear, grief, jealousy, intense anxiety and remorse. There is nothing more pleasant and invigorating than moderate exercise of all the organs; and when they are fatigued, there is nothing more grateful and refreshing than sleep. There is nothing more agreeable and salutary than fresh air, pure water, good bread, milk, eggs and other animal food when we are hungry, with a due proportion of vegetables and of ripe fruits in their season.

Again, when the temperature of the body and all the energies of life are reduced below the normal standard, as during the cold stage which ushers in nearly all diseases, or when the vital heat has been unduly expended by muscular exertion, what is so

delightful and well suited to rouse the torpor of the nearly suspended functions as the agent which causes the heart to beat, the stomach to digest, the muscles to contract, the nerves to feel and the brain to think? Or when the vital properties of the blood have been impaired by any of the remote and exciting causes of disease, what is so likely to restore its healthy state as the various means of augmenting respiration, by which it is renovated? And when owing to an interruption or diminution of the process by which the animal heat obtained in the lungs is transferred to the solids, the temperature of the body has been raised above the normal standard, as during fever, what so delightful and calculated to restore the nutritive process as fresh air, cooling ablutions, with refrigerating beverages, lemonade, soda-water, tamarind-water, l'eau sucrée, orange-juice, &c.?*

The great secret of a successful treatment consists

* In the life of Benevenuto Cellini, written by himself, he relates, that being reduced to the verge of death by a fever, at Rome, and given over by his physicians, he bribed a maid-servant to give him as much cold water as he could swallow, until his burning thirst was quenched. He then covered himself with bedclothes, perspired freely, fell asleep, and from that time was convalescent. On finding him so much better, and learning the cause, his favourite physician, Dr. Francisco, exclaimed: "O wonderful power of nature! She knows her own wants, and physicians know nothing." (*Page* 212.) The excellent work of Dr. Currie abounds with proofs, that fever may be arrested by the *judicious* employment of cold drinks, cooling ablutions, and immersion in cold water. I once had a patient with a burning fever, (which kept him awake for three successive nights,) who fell into a refreshing slumber during the act of pouring large quantities of cold water over him, while he reclined on a hard floor, covered only with a sheet.

in knowing what remedies are best adapted to restore the various functions to their natural state, and to promote the evacuation of morbid excretions, without impairing the vital properties of the blood. And as nearly all diseases are attended with more or less torpor of the bowels, mild aperients are often required, or even active purgatives, when the alvine excretions have been long retained.

To the honour of the medical profession, the most enlightened physicians of the present day, and especially those who attend the higher classes of society, are more sparing in the use of the lancet, leeches, the scarificator and poisonous drugs, than formerly. At the head of this class in England stands Sir James Clark, whose judicious practice has been justly rewarded by the patronage of the Queen; a selection which is alike honourable to both. But unfortunately for the mass of mankind, such is their ignorance in regard to the laws of health, that if their medical attendant do not dose them plentifully with nauseous compounds, they are almost sure to desert him and resort to some unscrupulous empiric, who mendaciously takes to himself the credit of all the *recoveries* performed by nature, and impudently calls them *cures*.

THEORY OF INFLAMMATION.

It was the opinion of both Hippocrates and Galen, that inflammation depends on an accumulation of blood in the small vessels, by which the natural action of the vital spirit in them is disturbed. Among the moderns, Sydenham, C. L. Hoffman and others, re-

ferred it to acidity or some morbid condition of the blood, which they never explained; while Stahl regarded it as a salutary process of nature to preserve the body from the effect of noxious agents. According to Walther, it is the blazing up of a previously *unknown vital fire;* which is about as explanatory as the prevalent theory, that "it consists essentially in an altered state of the vital properties of the arterial capillaries."

It was also maintained by Boerhaave and Gaubius, that the proximate cause of inflammation is a viscid state of the blood and an obstruction to its free passage through the capillaries of the diseased part. But this simple and almost self-evident view of the subject was rejected by Cullen, who observes, that "the phenomena of inflammation all concur in showing, that there is an increased impetus of blood in the vessels of the affected part; that as the proximate cause of fever is a spasm affecting the extreme vessels, and as every considerable inflammation is attended with symptoms of fever, it seems probable that a spasm of the extreme vessels is also the immediate cause of topical inflammations; that the phlogistic diathesis consists in an increased tone or contractility, and perhaps in an increased contraction of the muscular fibres of the whole arterial system." (*Practice of Physic,* sec. 239, 243, 247.)

That inflammation and fever are modifications of the same radical disease, and that both are generally attended with increased action of the heart, cannot be denied. It might even be said, that inflammation is a local fever and that idiopathic fever is a general

inflammation; for they are both ushered in with more or less of a cold stage, which is followed by a preternatural elevation of temperature. Nor is it less certain, that all extensive or serious local inflammations are attended with general fever, the leading symptoms of which are essentially the same as if produced by malaria. For example, pneumonia might be termed a lung fever; gastritis, a stomach fever; enteritis, a fever of the bowels; smallpox, erysipelas, &c. cutaneous fevers.

The opinion that local inflammation depends on increased action of the capillaries, and the circulation of a greater amount of blood through them than in the healthy state, was embraced by John Hunter, Abernethy, Richerand, Gendrin, Parry, Kaltenbrunner, James and Lawrence.* On the other hand, it was maintained by Vacea, Pistilli, Reil, Gregory, Allen, Lubbock, Philip, Hastings, Billing and some others, that inflammation is owing to debility and diminished

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* The opinion of Mr. Lawrence, that inflammation depends on increased action of the affected part, he regarded as confirmed by the experiment of simultaneously opening a vein in both arms of a patient who had inflammation in one hand, when a much larger amount of blood flowed from the diseased side than from the other. But may not the vein or the orifice have been larger in the one case than in the other? However this may have been, it is certainly not true that blood flows more freely from a vein during inflammation than at other times, except when the action of the heart and general circulation are greatly augmented. On the contrary, in the worst forms of inflammation, it flows at first with difficulty; showing that its motion has been retarded, and that the power of the heart is inadequate to propel it onward, until a portion of it is removed, when it runs more freely and changes to a brighter hue.

activity of the capillary circulation in the affected part. The most important experiments on the subject are those of Dr. Philip, who found that when inflammation was produced in the transparent web of a frog's foot, the fins and tail of fish or in the mesentery of a rabbit, by mechanical or chemical irritants, the small vessels became enlarged, congested with red blood, and its circulation more and more languid, until at length it entirely ceased. He also found, that when caused by exposure to a cold current of air, the diameter of the vessels was diminished; but that the velocity of the blood through them increased on directing upon the inflamed part the concentrated rays of the sun from the concave reflector of his microscope. (*Exp. Inquiry*, pp. 280, 288, 297, 381.) Yet this last experiment seems not to have called the attention of Dr. Philip to the important and very obvious conclusion, that caloric is the cause of circulation; and he maintains that blood is impelled through the capillaries by virtue of their own action; so that when weakened by cold, mechanical or chemical irritation, the velocity and momentum of the blood through them must be diminished or even wholly arrested in extreme cases. But I have proved that the immediate cause of capillary circulation resides in the blood and is owing to the transition of caloric from the blood to the solids, as in the process by which various liquids are forced through the pores and small tubes of dead matter; while it is admitted by many of the most accurate microscopic observers of the present time, that in their natural state no action of the capillaries can be perceived.

Again, that inflammation is always attended with diminished circulation in the affected part, would appear from the following general facts:—

1. That all the predisposing and exciting causes of inflammation produce debility, such as cold, the narcotic and other poisons, a severe burn, mechanical injuries, &c.*

2. That persons of feeble constitution are more liable to inflammations than the vigorous and sanguine, while it is equally certain that they generally fall upon the weakest organs of the same individual.†

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* Dr. G. Gregory observes, in his work on the *Practice of Physic*, that by far the most common exciting cause of rheumatism, gastritis, enteritis, dysentery, diarrhœa and every description of internal inflammation, is cold; the modus operandi of which, he says, is still involved in the greatest obscurity. (*Pages* 155, 259.) But we have seen that the invariable effect of cold or a deficient supply of caloric, is to diminish the circulation of any part; causing obstruction, effusion, tumefaction, tension and more or less pain. Nor is it less certain, that when they do not destroy life immediately, hydrocyanic acid, conia, oxalic acid, arsenic, bichloride of mercury and all the more active poisons, produce congestion or inflammation of the stomach and other parts to which they are applied; while it is worthy of notice, that the only difference between simple congestion and inflammation is, that the former is attended with little or no reaction, and no increase of temperature in the affected part, owing to diminished respiration and languor of the heart.

† For example, we have seen that individuals of narrow chest and weak lungs are far more liable to catarrh, influenza, pneumonia, phthisis, and all diseases of the respiratory organs, than such as have a large thorax, sound lungs and robust health; that when the stomach, bowels, liver and other abdominal viscera, have been weakened by exposure to a very warm or impure atmosphere, (or even the depressing emotions, fatigue and improper nourishment,)

3. That if the blood were conveyed through an inflamed part as rapidly as it is sent to it from the heart, there could be no accumulation of fluids and no congestion or swelling of the part.

4. That as the pulsating force of the radial artery is increased by compressing it at the wrist; and as violent throbbing of the heart is the immediate consequence of tying the aorta of an animal, the conclusion is inevitable, that any obstruction to the free circulation of blood must be attended with more or less throbbing of the affected part, as in all local inflammations. Hence it is, that when the brain has been seriously weakened by concussion, violent emotions of grief or intense thinking, and the free circulation of blood through it is impeded, there is a throbbing of the carotid arteries. And hence also it is, that when torpor of the stomach, bowels, liver and whole capillary system has been induced by impure

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they are extremely liable to congestion and inflammation, which are brought on by exposure to slight degrees of cold, or damp night air, as shown by the prevalence of cholera, gastritis, dysentery, diarrhœa and hepatitis, in hot climates and seasons. It is also well known that when the peritoneum has been long distended and weakened, as during utero gestation, and the whole system exhausted by parturition, women are very subject to peritonitis; and that when the brain is greatly debilitated by concussion, or by violent emotions of terror, grief, and other depressing passions, it is peculiarly liable to inflammation, which is likewise induced by sprains, bruises, lacerations, compound fractures, compression from a tight bandage, a severe burn, the action of caustics, and whatever disorganizes or greatly weakens the tissues. In fact, *the power of resisting the invasion of fever and inflammation, is in proportion to the vital energy of the individual; which depends on the free distribution of blood through the lungs and general system.*

air, want of sufficient nourishment or clothing, the depressing passions, &c. palpitation of the heart is caused by a slight degree of muscular exertion, which augments respiration and rouses the heart to send more blood to the capillaries than can freely pass through them, until stimulated by the warm bath and other appropriate remedies.

The leading symptoms of local inflammation are tumefaction, redness or a livid hue, increased temperature, pain, and more or less throbbing of the part, with a manifest diminution of secretion and nutrition. In nineteen cases out of twenty, it is brought on by the immediate influence of cold,* which retards the circu-

* And it must always be remembered, that the influence of cold is relative to the size of the lungs and general strength of the constitution; that the same temperature which diminishes respiration and the power of the heart in a feeble individual, produces directly opposite effects on persons of sanguine temperament; that after the muscles have been exhausted by over-exertion, or an excessive expenditure of vital energy, they are far more liable to rheumatic inflammation than at other times; in short, *that the morbid effects of cold air are in proportion to its influence in retarding the circulation of the part on which it operates.* The more rapidly caloric is abstracted, the higher is the temperature of the body at which the loss becomes fatal, because it is not supplied by respiration. It may also be observed, that the only difference between rheumatism and neuralgia is, that the one is confined chiefly to the investing membranes of the muscles, while the other depends on inflammation of the nerves, but is sometimes united with rheumatism, which is then more painful than usual. They are both to be treated by gradually restoring the free circulation of good arterial blood through the affected parts, and not by debilitating medicines. The modern practice of dividing the inflamed nerve in tic douloureux, should be shunned as a barbarous and unnecessary operation.

lation through the capillaries and diminishes their contractility. The consequence is, that they are dilated by means of the *vis a tergo*, engorged with blood, and tumefaction induced.* In the mean time, owing to the weakness and diminished cohesion of the vessels, there is an effusion of serum, lymph and sometimes of red blood, into the cellular tissue or other surrounding parts, by which the swelling is still further increased. In many cases of greatly impeded circulation or of complete obstruction to its passage, the blood coagulates in the semi-vitalized capillaries, as well as when extravasated. And as the onward motion of the blood is impeded, it is prevented from receiving the vitalizing influence of respiration, by which its nutritive properties are impaired; so that the animal heat sent to the part in combination with arterial blood, is not properly united with the solids, as during health, but given out in the free state, causing a local fever. Hence the redness, tension, swelling and heat, which are attended with more or less pain, owing partly to compression of the nerves, partly to morbid sensibility produced by the preternatural temperature, and still more, perhaps, to a failure of

* It has been said that the capillaries are not passively dilated by a *vis a tergo*, because in cases of contusion, the heat, sensibility and pulsations of the part, have been arrested for days, without any dilatation. But if the pulsations of the part have ceased, it is obvious that the capillaries no longer receive blood from the action of the heart. The reason of which is, that they have been ruptured and disorganized. Hence the absence of heat, swelling, redness, and of sensibility, which sometimes follow violent injuries of a part.

the nutritive process, any derangement of which is always accompanied with disagreeable sensations.

But how does local inflammation induce general fever? The prevalent belief has been, that morbid action is propagated from the primary seat of injury to other parts of the body by *sympathy*, which has generally been referred to nervous influence; that the operation of cold and moisture on the skin induces a sympathetic affection of the lungs, and thus lays the foundation of phthisis, or some other pulmonary disease; that the loss of appetite, nausea, and vomiting, which follow a blow on the head, intense grief, and other depressing emotions, are owing to sympathy of the stomach with the brain; that the headache which follows a debauch, a dose of tartar emetic, or some other noxious agent, is owing to sympathy with the morbid condition of the stomach; that when fever is induced by a compound fracture, or any other serious injury, it arises from sympathy with the affected part; and that when gastritis, enteritis, dysentery, diarrhœa or hepatitis, are brought on by exposure to cold, after the body has been weakened by over-exertion in the hot sun, they are owing to sympathy with the skin, &c.

But the word *sympathy*, as employed by pathologists, is merely an *asylum ignorantiæ*. Sir Charles Morgan truly observes, that "it is a primitive law of organization which admits of no other explanation than that which shall unfold the mystery of life itself." (*Philosophy of Life*, p. 244.)

The modus operandi of what is called morbid sympathy, may be illustrated by the following facts. In

the first place, when the feet have been exposed for some time to the influence of cold and moisture, the temperature of the whole body is gradually reduced by the abstraction of caloric, which is brought to them in combination with the blood, causing more or less torpor of the general circulation; so that if the lungs are in a feeble state, they become still further paralyzed, until congestion or inflammation is established, as in pneumonia and bronchitis, which are the usual forerunners of consumption. But as the blood is formed, renovated and purified in the lungs, it is evident that its free circulation through them must be greatly retarded, respiration diminished, and its vital properties impaired;* so that the animal heat, which in its natural state is employed in combining it with the solids, and in maintaining the various secretions,

* I have often observed that blood drawn from the arm during the advanced stages of pneumonia, bronchitis and pleurisy, was so far dissolved as to require from thirty minutes to an hour to coagulate, and then very imperfectly, when it presented the same appearances as in cases of typhus and other malignant fevers. The truth is, that local inflammation of the stomach, bowels, or of any important organ, whether produced by cold, mechanical violence, or the chemical agency of some poison, is attended with more or less obstruction in the affected part, by which a large amount of blood is prevented from passing through the lungs; the consequence of which is, that its nutritive properties are impaired, causing pain in the head, back and limbs, general debility, and other morbid symptoms; all of which are owing to a deranged action of the vital principle and of the blood through which it operates. I have also shown that, after a certain time, the coagulating power of the blood is more or less impaired in all cases of local congestion, inflammation, general fever, and, in fact, every form of disease. (See Book iv. chap. v. p. 590.)

is given out in the free state, causing more or less fever, prostration of strength, headache, delirium and a diseased condition of the whole body.

Again, as respiration is partly a voluntary process, it is diminished by concussion of the brain, or violent emotions of grief and other depressing passions. The consequence of which is, that the chemical function of the lungs, the supply of animal heat, sanguification, secretion and nutrition, are greatly diminished. Owing to the weakened state of the brain, the circulation through it is impeded; and as it is no longer supplied with good arterial blood, stupor, syncope or symptoms of apoplexy follow. When the injury has been so serious as nearly to arrest the process of breathing, the extremities remain cold, and the pulse feeble, for two or three days, or until death. And as the stomach is no longer supplied with good arterial blood, the secretion of gastric juice is arrested, causing a loss of appetite, nausea, or even vomiting. For the same reason, the voluntary muscles, being no longer duly nourished, lose the power of contraction, and the healthy state of all the functions is no less certainly destroyed than by a dose of arsenic, oxalic acid, or any of the narcotic poisons, which, as I have already shown, produce their deleterious effects by impairing the vital properties of the blood. And it is equally manifest that the hectic fever which attends phthisis is not owing to sympathy of the whole body with the primary affection of the lungs, but to a loss of the nutritive powers of the blood.

It has been long known, that rheumatism, gout, erysipelas and other local inflammations, are some-

times suddenly removed from the surface or extremities to the stomach, brain, heart, lungs, &c. by what has been called *metastasis*, the rationale of which is no less obscure than that of *sympathy*. By far the most frequent cause of this change or transfer of disease from superficial to deep-seated parts, is the local application of cold, when the body is in a feeble state. For example, we are informed by Dr. Robert Dick, of a gentleman with gout, who kept the affected foot in cold water for fifteen minutes, when the pain and swelling subsided; but that he was soon afterwards attacked with a feeling of oppression, weight and fullness in the region of the heart, from which he had not been able to relieve him; and that another gentleman of feeble constitution, who was labouring under rheumatism, was persuaded by some hydropathist to use the cold bath; soon after which he was attacked with disease of the heart and difficulty of breathing.* (*Lancet*, Nov. 12, 1842.)

That the application of cold to an inflamed part should relieve the pain for a time, is not in the least surprising, because it *deadens* the sensibility of the part. It also diminishes the swelling by its astringent

* Sir Francis Burdett also applied to a hydropathist, for the cure of gout, which was transferred from his extremities to the lungs and brain, under the cold water treatment, which was followed by hæmorrhage from the lungs, and next by delirium. His daughter, Miss Burdett Coutts, is reported in the *Times* of January 27, 1844, to have said that she had "no hesitation in asserting that the cold water treatment had destroyed one of the noblest constitutions ever given to man, and that it had reduced her father to a state of debility from which it was impossible for him to recover." (*Lancet*, Feb. 3, 1844.)

operation upon the capillaries, and by arresting the free passage of blood into them from the larger vessels. But as it reduces the activity of the circulation through the lungs, heart, stomach and all the other organs, they are rendered more liable to congestion or inflammation, especially if previously debilitated by intemperance or the abuse of drugs. And if the brain has been weakened by narcotics, the depressing emotions, or intense thinking; vertigo, headache, low spirits and even apoplexy, may be induced by undue exposure to cold. Many examples of metastasis are recorded by Armstrong, Parry, Scudamore and others, from the application of cold water, and exposure to damp air, in cases of gout, rheumatism and erysipelas; which are also produced by whatever greatly weakens the general powers of life in the more important organs.

I have already observed in a preceding chapter, that during the retreat from Moscow, the symptoms of approaching death among the French soldiers, from the united influence of cold, want of nourishment, and mental dejection, were diminished power of the heart, slow and imperfect respiration, a pale or purple hue of the surface, shrinking of the extremities, (in which, if inflammation had then existed, it would have disappeared,) loss of sensibility, coma, confusion of mind, delirium, spasms, hæmorrhage from the nose, mouth and ears, mortification of the extremities, universal coldness and torpor; that most of those who survived the march were attacked with rheumatism, inflammation of the lungs, pleuræ or throat, low fevers, deafness, impaired vision, neuralgia, paralysis, diarrhœa, &c.

In regard to the treatment of inflammation, the general indication is to remove the proximate cause, by increasing the circulation through the capillaries of the affected part, and thus promote resolution, before effusion, suppuration, ulceration or mortification come on.

In accordance with the fact which has been fully established in the foregoing parts of this work, that caloric is the cause of vital force by which blood is conveyed through every part of the body, it has been found to be by far the most important of all remedies in diminishing and preventing inflammation. Dr. John Thomson declares, that "in all inflammations of the abdominal viscera, there are no means of cure (blood-letting excepted) which afford such sudden and permanent relief as may be obtained from hot fomentations and warm bathing; that in cases of suppuration they shorten the process, and in all cases of severe pain afford singular relief; that it *seems doubtful whether fomentations and poultices have any power independently of their temperature.*" And he very properly recommends that the latter should not only be removed every few hours, but covered with several folds of flannel for retaining the warmth. Yet he adds, that the manner in which they act is unknown. (*Lectures on Inflammation*, pp. 173, 188, 332.) Mr. Lizars also makes use of hot anodyne fomentations in cases of inflammation, which he thinks essentially consists in *disturbance of the nerves.* (*Ed. Med. and Surg. Journal*, vol. x. p. 408.)

We are also informed by Dr. Macartney, in a recent work on the same subject, that in sprains, lacerations,

punctures, gun-shot wounds, contusions, fractures near joints, and all violent injuries attended with a shock to the nervous system, there is nothing so soothing and stimulating to the patient as the influence of steam, (at a high but comfortable temperature,) which removes all pain and consciousness of injury in a very short time; and, as might naturally be supposed, that it prevents traumatic tetanus. He adds, that the warm bath increases the action of the skin and all the other secretions, by *sympathy*.* (*Pages* 178, 193.)

But Thomson and Macartney are not the only practitioners who have given their testimony in favour of external warmth in the treatment of inflammation. In the *Archives Générales de Médecine* for October, 1835, there is an article on the influence of heated air on wounds and ulcers, by M. Jules Guyot, the substance of which he has reduced to the following propositions:—

"1. That wounds have always healed more rapidly when surrounded by air above 85° without dressing, than with or without dressing at lower temperatures.

"2. That some wounds have healed in a heated atmosphere, which have not done so at ordinary temperatures.

* The same doctrine has been embraced by Dr. Hugh L. Hodge, of Philadelphia. This accomplished physician maintains, that the increased action of the heart and general circulation, by exercise, the exciting passions, warm and hot baths, the internal use of wine, brandy and other diffusible stimulants, like the general fever that follows local irritation, are all produced by *sympathy*. (*North American Med. and Surg. Journ.*, vol. vi.) Well might Sir Charles Morgan say, that this process admits of no other explanation than that which shall unfold the *mystery of life itself*.

"3. That in the former state, the majority of wounds healed *without inflammation or suppuration, but not in the latter.*

"4. That *wounds have ceased to suppurate when exposed to heat, and undergone the same healing process as fresh wounds.*

"5. That *an ulcer will heal without any other local application than an increased temperature.*

"6. That heated air has caused the formation of a large cicatrix, in forty-eight hours, over an old ulcer; and in all cases is highly favourable to cicatrization.

"7. That instead of giving rise to inflammation, it checks its progress.

"8. That heat is useful in scrofula, rheumatism, white swellings, phthisis, amenorrhœa, paraplegia and other paralyses."

To those who are opposed to all reasoning on the first principles of medical science, it may be agreeable to learn that the practice of Dr. Macartney and M. Guyot was not adopted from any peculiar theoretical views in regard to the physiological agency of heat, but from clinical observation and experience. That blisters and rubefacients produce their good effects in deep-seated inflammations, by increasing the action of the capillary vessels, and thus relieving congestion, might naturally be inferred from the elevation of temperature they produce in the parts to which they are applied, and from their influence in augmenting the vigour of the general circulation. Sir Astley Cooper found, that the temperature of the parts on which blisters were applied, was from 4° to 7° higher than on covered parts not blistered. (*Cooper's Lect.*,

vol. i. p. 223.) Hence their utility in inflammation of the lungs, pleuræ, throat, brain, stomach, bowels, liver and other organs, as also in typhus, apoplexy, paralysis and other cases of languid circulation.

Another indication in the treatment of inflammation is to diminish the action of the heart when too violent, by which more blood is forced into the weakened vessels than can be circulated through them, and the local congestion augmented. This may be done by moderate blood-letting, which may also be resorted to in cases of extreme plethora, or when there is more blood than the heart has the power of forcing freely through the body. And local plethora may be relieved by the application of leeches, should fomentations fail. But we ought never to bleed in health, because blood is the immediate source of life and power to all the organs; and very rarely in disease, because the process of sanguification is then diminished. Cullen rightly observes, that in pneumonia it favours effusion into the bronchial cells and prevents expectoration, when carried too far.* Hunter also says, that excessive bleeding often induces dropsy and convulsions; while Dr. M'Culloch assures us, that it causes delirium, paralysis and madness.

* In regard to the beneficial influence of mercury in removing the effusion of lymph in cases of croup, pneumonia, bronchitis, pleurisy, peritonitis, pericarditis, hepatitis and iritis, Dr. Alison truly observes, that there has been much exaggeration; that when given so as to produce salivation, it is oftener followed by an aggravation than by an improvement of the symptoms; that it frequently causes a dysenteric affection of the bowels, and produces or augments scrofula, when there is a tendency to that disease. (*Cyclopedia of Medicine*, part xxiv. p. 96.)

In fact, the records of medicine abound with proofs, that paralysis is far more frequently produced by hæmorrhage, excessive use of the lancet, over-exertion, and by a deficiency or altered state of the blood, than by plethora, or what is improperly called a *determination of blood to the head*, which is nothing more nor less than an *obstruction to its* free passage through the head, where it very soon becomes unfit to nourish the brain, because prevented from being renovated in the lungs. Before using the lancet or scarificator, we should ask ourselves whether such are the best means for overcoming the torpor and congestion of the diseased part, equalizing the circulation, and restoring the blood to its normal state. If not, we do more harm than good. And Sir Everard Home found, that on exposing the back of his hand to the sun at twelve o'clock, for forty-five minutes, blisters arose, and coagulable lymph was thrown out. (*Lect. on Comp. Anat.*, iii. 217, Lond. 1823.)

The leading object should always be to restore the action of the weakened vessels, by a judicious and varied application of the agent on which all the powers of life depend. Perhaps there is no better method of treating old ulcers than by frequent fomentations, the application of simple cerate, and wrapping the affected limb with a flannel roller, which is not only more warm, but more elastic than a cotton bandage.

And now that I have brought this laborious undertaking to a close, it remains for competent judges to decide how far the principles developed have been founded on a legitimate and comprehensive induction

from facts. If true, they must be realized in all the practical concerns of human life, but more especially in improved methods of preserving health and curing diseases. Animated by the grandeur of the subject, and a deep conviction of its vast importance to the welfare of mankind, I have committed myself with unreserved confidence to the guidance of nature, undismayed by the magnitude of the enterprise; believing with Bacon, that in science, as "in the affairs of civil government, it is better to change many things than one;" and with Sir Edward Lytton Bulwer, that "there does not exist one prejudice which can be called salutary, nor one error beneficial to perpetuate." (*The Disowned*, chap. xxii.)

During the prosecution of this task, I have been often reminded of the many deeply-rooted prejudices by which the reformer is surrounded; that the mass of mankind have in all past ages been ungrateful to their best friends; that it is generally a thankless office to oppose opinions long sanctioned by custom and the authority of distinguished names. To all such admonitions I would reply in the words of Sydenham, that "it is better to assist mankind than to be commended by them;" and that I dare not suppress truths which are essential to human happiness. If the multitude have been always fond of mysteries, fables, traditions and quack doctors, it is because their leaders have permitted the great science of nature to remain a sealed book; the profoundest of all mysteries. But when the veil which has so long concealed the beautiful mechanism of the universe shall have been drawn aside, all subordinate mysteries will vanish,

and with them a countless multitude of pernicious errors, which have hitherto obstructed every avenue to the temple of wisdom. Nor can there be a rational doubt, that a complete knowledge of the Prime Mover would be the perfection of science, and give to man his legitimate empire over nature.

It must not, however, be supposed, that more than a general outline of this immense subject has been attempted in the present work. Nor does the author presume to flatter himself that he has been always free from error. Nor should it be expected that the pioneer of unexplored regions can become so fully acquainted with all their various productions as those who follow, and have more leisure for research into details.

When the extreme difficulty of the inquiry is duly considered, and the results obtained are contrasted with the previous state of our knowledge, it is hoped that men of enlarged views will be more studious to correct than to censure.

APPENDIX.

It has not been thought proper to make any essential alteration of the text as left by the author; the following notes have been added, for the purpose of supplying a few omissions, and giving certain facts developed by recent investigation. It has not been deemed advisable to discuss the peculiar views of the author, which are not, in some cases, in accordance with those generally received B. H. R.

Dynamical Theory of Heat, (p. 18.)—The following abstract, taken from the supplement to Graham's Chemistry, 2d Am. Ed., 1858, p. 654, will give an idea of this theory in its latest form.

The leading points of the theory may, perhaps, be sufficiently elucidated by the following summary of two remarkable papers lately published in "Poggendorf's Annalen," one by Krönig, entitled "Fundamental Principles of a Theory of Gases;"* the other by Clausius, "On the Kind of Motion which we call Heat."†

First, then, it is assumed that the particles of all bodies are in constant motion, and that this motion constitutes heat, the kind and quantity of the motion varying according to the state of the body, whether solid, liquid, or gaseous.

In gases, the molecules—each molecule being an aggregate of atoms—are supposed to be constantly moving forward in straight

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* Grandzüge einer Theorie der Gase. Von A. Krönig; Pogg. Annal. xcix. 315.

† Ueber die Art der Bewegung welcher wir Wärme nennen. Von R. Clausius; Pogg. Ann. C. 353. See also a former paper by Clausius, "Ueber die bewegende Kraft der Wärme." Ibid., lxxix. 394

lines, and with a constant velocity, until they impinge against each other, or against an impenetrable wall. This constant impact of the molecules produces the expansive tendency or elasticity which is the peculiar characteristic of the gaseous state. The rectilinear movement is not, however, the only one with which the particles are affected. For the impact of two molecules, unless it take place exactly in the line joining their centres of gravity, must give rise to a rotatory motion; and, moreover, the ultimate atoms of which the molecules are composed may be supposed to vibrate within certain limits, being in fact, thrown into vibration by the impact of the molecules. This vibratory motion is called by Clausius the *motion of the constituent atoms* (Bewegungen der Bestandtheile.) The total quantity of heat in the gas is made up of the progressive motion of the molecules, together with the vibratory and other motions of the constituent atoms; but the progressive motion alone, which is the cause of the expansive tendency, determines the temperature. Now the outward pressure exerted by the gas against the containing envelope, arises, according to this hypothesis, from the impact of a great number of gaseous molecules against the side of the vessel. But at any given temperature, that is, with any given velocity, the number of such impacts taking place in a given time must vary inversely as the volume of the given quantity of gas; hence *the pressure varies inversely as the volume, or directly as the density*, which is Mariotte's law.

When the volume of the gas is constant, the pressure resulting from the impact of the molecules is proportionate to the sum of the masses of all the molecules multiplied into the squares of their velocities; in other words, the so-called *vis viva* or *living force* of the progressive motion. If, for example, the velocity be doubled, each molecule will strike the sides of the vessel with a two-fold force, and its number of impacts in a given time will also be doubled; hence, the total pressure will be quadrupled.

Now we know that when a given quantity of any perfect gas is maintained at a constant volume, it tends to expand by $\frac{1}{273}$ of its bulk for each degree Centigrade. Hence the pressure or elastic force increases proportionately to the temperature reckoned from —273°C.; that is to say, to the absolute temperature. Consequently

the *absolute temperature is proportional to the vis viva of the progressive portion.*

Moreover, as the motions of the constituent particles of a gas depend on the manner in which its atoms are united, it follows that in any given gas the different motions must be to one another in a constant ratio; and therefore that the vis viva of the progressive motion must be an aliquot part of the entire *vis viva* of the gas; hence, also, the absolute temperature is proportional to the total vis viva arising from all the motions of the particles of the gas. From this it follows that the quantity of heat which must be added to a gas of constant volume in order to raise its temperature by a given amount, is constant and independent of the temperature; in other words, the specific heat of a gas, referred to a given volume, is constant—a result which agrees with the experiments of Regnault. This result may be otherwise expressed as follows: *The total vis viva of a gas is to the vis viva of the progressive motion of the molecules, which is the measure of the temperature, in a constant ratio.* This ratio is different for different gases, and is greater as the gas is more complex in its constitution; in other words, as its molecules are made up of a greater number of atoms. The specific heat referred to a constant pressure is known to differ from the true specific heat only by a constant quantity.

The relations just considered between the pressure, volume, and temperature of gases, presuppose, however, certain conditions of molecular constitution which are, perhaps, never rigidly fulfilled; and, accordingly, the experiments of Magnus and Regnault show that gases do exhibit slight deviations from Gay-Lussac and Mariotte's laws. What the conditions are which strict adherence to these laws would require, will be better understood by considering the differences of molecular constitution which must exist in the solid, liquid and gaseous states.

A movement of the molecules must be supposed to exist in all three states. In the solid state, the motion is such that the molecules oscillate about certain positions of equilibrium, which they do not quit unless they are acted upon by external forces. The vibratory motion may, however, be of a very complicated nature. The constituent atoms of a molecule may vibrate separately; the entire molecules may also vibrate as such about their centres of

gravity, and the vibrations may be either rectilinear or rotatory. Moreover, when extraneous forces act upon the body, as in shocks, the molecules may permanently alter their relative positions.

In the liquid state the molecules have no determinate positions of equilibrium. They may rotate completely about their centres of gravity, and may also move forward into other positions. But the repulsive action arising from the motion is not strong enough to overcome the mutual attraction of the molecules and separate them completely from each other. A molecule is not permanently associated with its neighbours, as in the solid state; it does not leave them spontaneously, but only under the influence of forces exerted upon it by other molecules, with which it then comes into the same relation as with the former. There exists, therefore, in the liquid state, a vibratory, rotatory, and progressive movement of the molecules, but so regulated that they are not thereby forced asunder, but remain within a certain volume without exerting any outward pressure.

In the gaseous state, on the other hand, the molecules are removed quite beyond the sphere of their mutual attractions, and travel onward in straight lines according to the ordinary laws of motion. When two such molecules meet, they fly apart from each other, for the most part with a velocity equal to that with which they came together. The perfection of the gaseous state, however, implies: 1. That the space actually occupied by the molecules of the gas be infinitely small in comparison with the entire volume of the gas. 2. That the time occupied in the impact of a molecule, either against another molecule or against the sides of the vessel, be infinitely small in comparison with the interval between any two impacts. 3. That the influence of the molecular forces be infinitely small. When these conditions are not completely fulfilled, the gas partakes more or less of the nature of a liquid, and exhibits certain deviations from Gay-Lussac's laws. Such is, indeed, the case with all known gases; to a very slight extent with those which have not yet been reduced to the liquid state; but to a greater extent with vapors and condensable gases, especially near the points of condensation.

Let us now return to the consideration of the liquid state. It has been said that the molecule of a liquid, when it leaves those

with which it is associated, ultimately takes up a similar position with regard to other molecules. This, however, does not preclude the existence of considerable irregularities in the actual movements. Now, at the surface of a liquid, it may happen that a particle, by a peculiar construction of the rectilinear, rotary and vibratory movements may be projected from the neighbouring molecules with such force as to throw it completely out of their sphere of action, before the projectile velocity can be annihilated by the attractive force which they exert upon it. The molecule will then be driven forward into the space above the liquids as if it belonged to a gas, and that space, if originally empty, will, in consequence of the action just described, become more and more filled with these projected molecules, which will comport themselves within it exactly like a gas, impinging and exciting pressure upon the sides of the envelope. One of these sides, however, is formed by the surface of the liquid; and, when a molecule impinges upon this surface, it will in general not be driven back, but retained by the attractive forces of the other molecules. A state of equilibrium, not static, but dynamic, will therefore be attained, when the number of molecules projected in a given time into the space above, is equal to the number, which in the same time, impinge upon and are retained by the surface of the liquid. This is the process of vapourization. The density of the vapour required to insure to compensation just mentioned, depends upon the rate at which the particles are projected from the surface of the liquid, and this again upon their rapidity of movement within the liquid—that is to say, upon the temperature. It is clear, therefore, that the density of a saturated vapour must increase with the temperature.

If the space above the liquid is previously filled with a gas, the molecules of this gas will impinge upon the surface of the liquid, and thereby exert pressure upon it; but as these gas molecules occupy but an extremely small portion of the space above the liquid, the particles of the liquid will be projected into that space almost as if it was empty. In the middle of the liquid, however, the pressure of the gas acts in a different manner. There it may also happen that the molecules may be separated with such force as to produce a small vacuum in the midst of the liquid. But this space is surrounded on all sides by masses which afford no passage to the

disturbed molecules; in order that they may increase to a permanent vapour bubble, the number of molecules projected from the inner surface of the vessel must be such as to produce a pressure outward equal to the external pressure tending to compress the vapour bubble. The boiling point of the liquid will, therefore, be higher, as the external pressure is greater.

According to this view of the process of vapourization it is possible that a vapour may arise from a solid as well as from a liquid; but it by no means necessarily follows that vapour must be formed from all bodies at all temperatures. The force which holds together the molecules of a body may be too great to be overcome by any combination of molecular movements, so long as the temperature does not exceed a certain limit.

The *production* or *consumption of heat* which accompany changes in the state of aggregation, or of the volume of bodies, are explained according to the preceding principles, by taking account of the *work* done by the acting forces. This work is partly *external* to the body, partly *internal*. To consider first the *internal* work:—

When the molecules of a body change their relative positions, the change may take place either in accordance with or in opposition to the molecular forces existing within the body. In the former case the molecules, during the passage from one state to the other, have a certain velocity communicated to them which is immediately converted into heat; in the latter case, the velocity of their movement, and consequently the temperature of the body, is diminished. In the passage from the solid to the liquid state the molecules, although not removed from the spheres of their mutual attractions, nevertheless change their respective positions in opposition to the molecular forces, which forces have, therefore, to be overcome. In evaporation a certain number of the molecules are completely separated from the remainder, which again implies the overcoming of opposite forces. In both cases, therefore, work is done, and a portion of the *vis viva* of the molecules, that is, of the heat of the body, is lost. But when once the perfect gaseous state is attained, the molecular forces are completely overcome, and any further expansion may take place without internal work, and therefore without loss of heat, provided there is no external resistance.

But in nearly all cases of change of state or volume, there is a

certain amount of external heat to be overcome, and the consequent loss of heat. When the pressure of a gas, that is, the impact of its atoms, is exerted against a movable obstacle, as a piston, the molecules lose just so much of the moving forces as they have imparted to the piston, and consequently their velocity is diminished and the temperature lowered.

On the contrary, when the gas is compressed by the motion of a piston, its molecules are driven back with greater velocity than that with which they impinged upon the piston, and consequently the temperature of the gas is raised.

When a liquid is converted into vapour, the molecules have to overcome the atmospheric pressure, or other external resistance, and in consequence of this, together with the internal work already spoken of, a large quantity of heat disappears, or is rendered latent, the quantity thus consumed being to a considerable extent affected by the external pressure. The liquefaction of a solid not being attended with much increase of volume, involves but little work; nevertheless, the atmospheric pressure does influence to a slight amount, both the latent heat of fusion and the melting point.

Mechanical Equivalent of Heat, (p. 24.)—From the experiments alluded to in the note, Rumford concluded that the mechanical equivalent of heat was 1034 foot pounds.

The subject has been since fully investigated by Haldot, Pictet, Meyer, Regnault, Kupffer, Joule, Rankin and others. The most complete experiments on the subject are those of Mr. J. R. Joule, of Manchester, England. His conclusions are :*

1. That the quantity of heat produced by the friction of bodies, whether solid or liquid, is always proportional to the force expended. 2. That the quantity of heat capable of increasing the temperature of one pound of water (weighed in vacuo and between 55° and 60° F.) by 1° F. requires for its evolution the expenditure of a mechanical force represented by the fall of 772 pounds through the space of one foot; or 772 foot pounds. This is called the mechanical equivalent of heat or the effect of an "unit" of heat.

Specific Heat, (p. 85.)—The specific heat of a body varies with its density, crystalline form, &c.

* Philos. Transactions, 1850, 1. 61.

Regnault* found that the specific heat of copper was sensibly diminished by hammering it; its value was restored by heating.

De la Rive and Marcet† found that the specific heat of varieties of carbon varied, being in general lower in the denser forms. The same results were obtained by Regnault, as will be seen by the following table :—

SPECIFIC HEAT OF VARIETIES OF CARBON.

Animal charcoal	0·26085
Wood charcoal	0·24150
Coke	0·20307
Charcoal from anthracite	0·20146
Graphite, natural	0·20187
Graphite of gas retorts	0·20360
Graphite of iron furnaces	0·19702
Diamond	0·14687

Specific heat increases with the temperature. This has been found to be true of most solids and liquids; but, according to Regnault,‡ the specific heat of gases does not vary either with their density or temperature.

The specific heat of water at different temperatures has been determined by Regnault,§ from whose experiments it appears that the quantity of heat expressed in heat units (the quantity of heat necessary to raise one gramme of water one degree Cent.) which one gramme of water loses in cooling down from t° to 0°C. is given by the formula—

$$Q=t\times 0{\cdot}0002t^2\times 0{\cdot}0000003t^3;$$

and the specific heat C, at the temperature t°, that is to say, the quantity of heat required to raise one gramme of water from t° to (t×1°), is—

$$C=1\times 0{\cdot}00004t\times 0{\cdot}0000009t^2.$$

From this formula the following numbers are obtained :—

t.	Q.	C.	t.	Q.	C.
0°	0·000	1·0000	150°	151·462	1·0262
50°	50·087	1·0042	200°	203·200	1·0440
100°	100.500	1·0130	230°	234·708	0·0568

* Annales de Chimie, etc., t. lxxiii. p. 5, and 3d sér. t. i. p. 129.

† Do. t. lxxv. p. 242.

‡ Comptes Rendus, xxxvi. 676.

§ Relations des Expériences, etc.; Paris, 1847, p. 249.

The same experimenter has also ascertained that the specific heat of most bodies is greater in the liquid than in the solid form.

Specific Heat of Atoms, (p. 89.)—The variation of specific heat in the same body and the difficulty of determining with positive accuracy its atomic weight, render the solution of the problem of the specific heat of atoms a difficult one. The atomic numbers at present adopted differ considerably in some cases from those given in the text. Numerous accurate determination have fixed that of chlorine at 35·5 on the hydrogen scale, and it becomes necessary to admit fractional numbers in this scale.

The researches of Dulong and Petit have been extended by Regnault* to compound bodies. The general law is thus announced by M. Regnault: "In all compound bodies of the same atomic composition and similar chemical constitution, the specific heats are inversely as the atomic weight." This law comprehends a particular case, that of Dulong and Petit. If we add the words "or in a multiple or submultiple ratio," these laws may be considered as demonstrated by experiment.

Atomic Volume of Solid Bodies.—The researches of Dr. Hermann Kopp, of Giessen,† led him to announce as a law, that the specific weight of isomorphous bodies is proportional to their atomic weight; or, isomorphous bodies possess the same atomic volume. This law, although shown to hold good in many cases, cannot be said, as yet, to be demonstrated. "Much of the uncertainty arises from the specific gravity of a body in the solid form being often variable between rather wide limits. Thus platinum, in a pulverulent state, reduced from its oxide and from the double chloride of platinum and ammonium respectively, is found to have the specific gravity 17·966 in the first case, and 21·206 in the second, (Playfair and Joule;) and the effect of compression upon the malleable metals is generally very sensible. As the rate of dilatation of different solids and liquids is very dissimilar, it is ob-

* Annales de Chimie, t. lxxiii. p. 5; 3me sér. t. i. p. 129.

† Bemerkungen zur Volumtheorie; Braunschweig, 1844.

vious that their relations in density may also be disturbed or disguised by temperature." (Graham.)

Relation of Atomic Heat to Crystalline Form.—An able and elaborate paper on this subject will be found in the Journal of the Academy of Natural Sciences, of Philadelphia, new series, vol. iii. part 2. Limited space will only allow of the introduction of the deductions of the author, these are—

"1. That no invariable connection exists between the form and ponderable atomic constitution of a body.

2. That form is immediately dependent upon peculiar axal proportions, which are themselves the results of a certain molecular arrangement.

3. That the arrangement and disarrangement of atoms implies a motor agent; while the definite and constant relation between changes in aggregation, and variations in form, implies the materiality of this agent and its continued presence, whether in the same or varying quantities.

4. That this agent has periods of action and periods of rest.

5. That caloric is a positive material entity—an essential element in all bodies, always present in different proportions.

6. That caloric is self-repellant and endowed with great physical power.

7. That crystalline form is the visible representative of atomic volume.

8. That isomorphous bodies have visibly the same atomic heat and the same atomic volume.

9. That in elementary and compound isomorphous groups, the members indicating atonic heat and volume are simply related.

10. That two or more atoms of one element may replace one of another, and retain the same figure; and vice versa; hence, equal numbers of atoms are not essential to isomorphism.

11. That similarity of constitution is generally, though not always, accompanied by sameness of combined heat.

12. That at certain temperatures the elements may all be made to assume the same form.

13. That variation in the atomic heat of a body is accompanied by variation in its form.

14. That atomic heat is the cause of isomorphism and polymorphism, consequently of crystalline form in general.

Influence of Chemical Composition on the Boiling Point, (p. 146.)—A series of bodies containing carbon and hydrogen and which differ in composition by $C_2 H_2$, or a multiple thereof, is called an Homologous series. The generic term *ether* is given to the oxide of a supposed radical containing carbon and hydrogen, the number of atoms in the former being even, in the latter odd; the hydrate of this ether is known as the alcohol of the series, and by the oxidation of this alcohol an acid is formed in which the amount of hydrogen is two equivalents less than in the original radical, and the amount of oxygen two equivalents more than in the alcohol. By the union of these acids with the ethers we have a series of compound ethers which will be in many cases *metameric* with each other or with other acids. The following example will illustrate these views:—

	Radical.	Ether.	Alcohol.	Acid.
General formula	$C_{2n}H_{2n}+1$	$C_{2n}H_{2n}+1\,O$	$C_{2n}H_{2n}+1\,O,HO$	$C_{2n}H_{2n}+1\,O_3,HO$
Methyl series	C_2H_3	C_2H_3O	C_2H_3O,HO	$C_2HO_3.HO$
Ethyl series	C_4H_5	C_4H_5O	C_4H_5O,HO	$C_4H_3O_3.HO$
Propyl series	C_6H_7	C_6H_7O	C_6H_7O,HO	$C_6H_5O_3.HO$
Butyl series	C_8H_9	C_8H_9O	$C_8H_{10}O,HO$	$C_8H_7O_3,HO$
Amyl series	$C_{10}H_{11}$	$C_{10}H_{11}O$	$C_{10}H_{11}O,HO$	$C_{10}H_9O_3,HO$

The general results of experiment have shown that for each increment of $C_2 H_2$ the boiling point rises about 19°C. This is true of the ethers, the alcohols, the acids, and the compound ethers.

Methyl Alcohol	C_2H_3O HO	boils at 60°C.
Ethyl Alcohol	C_4H_5O HO	boils at 78°4
Propyl Alcohol	C_6H_7O HO	boils at 96°
Amyl Alcohol	$C_{10}H_{11}O$ HO	boils at 132°
Formic acid	$C_2H_3O_3$ HO	boils at 98°5
Acetic acid	$C_4H_3O_3$ HO	boils at 118°
Propionic acid	$C_6H_5O_3$ HO	boils at 140°
Butyric acid	$C_8H_7O_3$ HO	boils at 156°
Valeric acid	$C_{20}H_9O_3$ HO	boils at 175°

It will also be seen by the above examples that the boiling point of the acid of a series is on the average 40°C. higher than that of the corresponding alcohol.

The following compound ethers are metameric, that is, they have the same empirical formula, while their rational formulæ differ:—

Acetate of Methyloxide	$C_2H_3O,C_4H_3O_3=C_6H_6O_4$	boils at 55°C.
Formate of Ethyloxide	$C_4H_5O,C_2H_1O_3=C_6H_6O_4$	boils at 55°
Butyrate of Methyloxide	$C_2H_3O,C_8H_7O_3=C_{10}H_{10}O_4$	boils at 93°
Acetate of Propyloxide	$C_6H_7O,C_4H_9O_3=C_{10}H_{10}O_4$	boils at 93°
Valerate of Methyloxide	$C_2H_3O,C_{10}H_9O_3=C_{12}H_{12}O_4$	boils at 112°
Butyrate of Ethyloxide	$C_4H_5O,C_8H_7O_3=C_{12}H_{12}O_4$	boils at 112°
Acetate of Butyloxide	$C_8H_9O,C_4H_3O_3=C_{12}H_{12}O_4$	boils at 112°
Formate of Amyloxide	$C_{10}H_{11}O,C_2HO_3=C_{12}H_{12}O_4$	boils at 112°

It will also be observed that the boiling point of a compound ether is lower by an average of 82°C. than its metameric acid.

Propionic acid	$C_6H_5O_3$	$HO=C_6H_6O_4$	boils at 137°C.
Acetate of Methyloxide	$C_2H_3O_1$	$C_4H_3O_3=C_6H_6O_4$	boils at 55°C.

In regard to the heat evolved by the combustion of isomeric, polymeric or metameric bodies, the researches of MM. Favre and Silbermann have led them to the following conclusions:—

That for every time that the elements of the carbide C_2 H_2 enter once more into the constitution of a new polymeric carbide the heat of combustion diminishes 67·5 units. The unit of heat is obtained by dividing the difference of the heat of combustion of two polymeric hydrocarbons by the multiples of C_2 H_2 existing in this difference. The following examples will illustrate this law, which, however, does not hold good strictly; the numbers obtained by experiment being somewhat higher than those calculated, a result due doubtless to the latent heat of vapourization of the gas.*

Hydrocarbon.		Units of Heat.
Amylene	$C_{10}H_{10}=(C_2H_2)\times5$	20683·8
Paramylene	$C_{20}H_{20}=(C_2H_2)\times10$	20346·8=20683·8—(5 ×67·5)
Cetene	$C_{32}H_{32}=(C_2H_2)\times16$	19941·3=20683·8—(11×67·5)
Metamylene	$C_{40}H_{40}=(C_2H_2)\times20$	19671·3=20683·8—(15×67·5)

The heat evolved by the combustion of isomeric bodies is not the same, in other words, isomerism does not involve equality of heat in combustion.

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* Lardner's Hand-book of Heat, p. 175.

Acetic Acid	$C_4H_4O_4$	6309	units of heat.
Formate of Methyloxide	$C_4H_4O_4$	7554·6	units of heat.
Propionic acid	$C_6H_6O_4$	8406	units of heat.
Formate of Ethyloxide	$C_6H_6O_4$	9502·2	units of heat.
Acetate of Methyloxide	$C_6H_6O_4$	9619·2	units of heat.

These discrepancies are to be ascribed to differences in molecular arrangement, and in the degree of condensation.

Attraction and Repulsion, (p. 163.)—The theorem of Laplace is not stated by the author. According to it the form of aggregation of a body depends upon the mutual relation of three forces. 1. The attraction of each particle for the other particles which surround it, which induces them to approach as near as possible to each other. 2. The attraction of each particle for the heat which surrounds the other particles in its neighbourhood. 3. The repulsion between the heat which surrounds each particle and that which surrounds the neighbouring particles,—a force which tends to disunite the particles of bodies. When the first of these forces prevails, the body is solid ; if the quantity of heat augment, the second force becomes dominant, the particles then move among each other with facility, and the body is liquid. While this is the case, the particles are still retained by the attraction for the neighbouring heat, within the limits of the space which the body formerly occupied, except at the surface where the heat separates them, that is to say, occasions evaporation, until the influence of some pressure prevents the separation from being effected. When the heat increases to such a degree that the reciprocal repulsive force prevails over the attraction of the particles for one another, they disperse in all directions as long as they meet no obstacle, and the body assumes the gaseous form. Some curious experiments were made by M. Cagniard de la Tour on the vapour from various liquids at very high temperatures and under great pressures. He filled a small glass tube in part with ether, alcohol or water, and sealed it hermetically. The tube was then exposed to heat until the liquid passed entirely into vapour. Ether became gaseous in a space scarcely double its volume at a temperature of 320° F., and the vapour exerted a pressure of no more than 38 atmospheres. Alcohol became gaseous in a space almost thrice its volume at a temperature of $404\frac{1}{2}°$ with

a pressure of about 139 atmospheres; water acted chemically on the glass and broke it; but after adding a little carbonate of soda to it, the water became gaseous in a space four times its volume at the temperature at which zinc melts, or about 648°.

De la Tour announced the following as the result of his experiments: There is for every vapourizable liquid a certain temperature and pressure at which it may be converted into the aeriform state, in the same space occupied by the liquid.* This is an important exception to Mariotte's law, (p. 81,) showing that highly compressed vapours lose a portion of their elasticity or yield more to a certain pressure than air by calculation would do. Berzelius† suggests as an explanation of these results that as the particles have not an opportunity to recede much, the two first forces of Laplace continue always to act and oppose the tension of the gas, which does not establish itself in all its forces, unless when the particles are so distant from each other as to be out of the sphere of the influence of these forces.‡

Electrolysis, (p. 192.)—Faraday has shown that in any voltaic arrangement the quantity of electricity evolved is proportional to the amount of chemical action in the cells, and vice versa. Thus, in an ordinary battery, for each equivalent of zinc dissolved an equivalent of water is decomposed, and an equivalent, so to speak, of electricity liberated. If the conducting wire be broken and its ends immersed in any liquid capable of conducting electricity and of being decomposed by it, (an electrolyte,) the amount of decomposition will be proportional to that going on in the cell. Thus, for every 32 grains of zinc dissolved in the battery cell, nine grains of water will be decomposed, eight grains of oxygen uniting with the 32 of zinc and one grain of hydrogen passing off at the negative plate, the electricity thus evolved will, if caused to pass through water, decompose nine grains as in the cell, but if through iodide of potassium, will decompose 166 grains, setting free 127 grains (one equivalent) of iodine and 39 grains (one equivalent) of potassium. Hence a cell containing an electrolyte interposed in

* Silliman's Natural Philosophy, p. 403.

† Traité de Chimie, t. i. p. 85.

‡ Graham, op. cit., pp. 68, 76.

the circuit is made an exact measure of the amount of electricity passing and of the chemical action going on in the cell. These facts show a close relation between the electrical force and chemical affinity. In regard to the electrical classification of bodies it should be borne in mind that the terms electro-positive and electro-negative are relative and not absolute; we cannot conceive of one form of electro-polarity without the other. Hence the objection often urged against the Franklinian theory of electricity, that as two negatively electrified bodies mutually repel, therefore matter alone will repel matter,* is founded in error, since the repulsion of the two bodies is rather apparent than real, and may be dependent on the attraction of relatively positive surrounding bodies. It is obvious, therefore, that while chlorine may be electro-negative to positive hydrogen it may also be positive to a more electro-negative body, oxygen.

Osmose, (p. 246.)—The phenomena of endosmose and exosmose are complex. They probably depend—First, *on capillary attraction*, the liquid which has the most adhesion to the material of the porous septum more readily forcing its way through into the less adherent liquid. But osmose is increased by heat, which diminishes capillary attraction. Secondly, *on the diffusive tendency of the liquids.* The experiments of Mr. Graham† on this subject lead him to the following conclusions:—

1. Different salts in solutions of equal strength diffuse unequally at different times.

2. With each salt the rate of diffusion increases with the temperature, and at any given temperature is proportionate to the strength of the solution, at least when the quantity of salt dissolved does not exceed 4 or 5 per cent.

3. There exist classes of equidiffusive substances which coincide in many cases with the isomorphous groups, but are on the whole more comprehensive than the latter. Thus the same rate of diffusion is established by hydrochloric, hydrobromic and hydriodic acids; by the chlorides, iodides, and bromides of the alkali metals; by the

* Silliman's Natural Philosophy, p. 573.

† Phil. Trans., 1850, pp. 1, 805.; Chem. Soc.; Qu. J. ii., 60, 257.; op. cit., 743.

nitrates of baryta, strontia and lime; the sulphates of magnesia and zinc, &c. &c.

4. In several groups of salts it is found that the squares of the times of equal diffusion from solutions of the same strength, stand to each other in a simple numerical relation. Mr. Graham's experiments* have shown that the squares of the times of equal diffusion of gases are to one another in the ratio of their densities Hence he infers by analogy that the molecules of these several salts, as they exist in solution, possess densities which are to one another as the squares of the times of equal diffusion. Thus the *solution-densities* of sulphate, nitrate and hydrate of potassa are to each other as the numbers 4, 2 and 1. These solution-densities appear to relate to a kind of molecules different from the chemical atoms, and the weights of which are either equal or bear to one another a simple numerical relation. The diffusion of a salt into a solution of another salt takes place with nearly the same velocity as into pure water; at least when the solutions are diluted. The rate of diffusion, however, is materially affected when the liquid atmosphere already contains a portion of the diffusing salt. The consideration of this case leads to the general question of the motion of particles of a dissolved substance in a solution of unequal concentration.

The general law which regulates such movements appears to be this: The velocity with which a soluble salt diffuses, from a stronger into a weaker solution, is proportional to the difference of concentration between two contiguous strata.

Thirdly, *on the chemical action of the liquids upon the septum.* The very accurate experiments of Mr. Graham† lead him to the conclusion that the phenomena of osmose depend essentially upon the chemical action of the liquid on the septum. He found that in solutions of neutral organic substances in general, such as sugar, alcohol, urea, tannin, &c., exhibited, when using a porous earthenware septum, very slight osmose; so also the neutral salts of the earths and ordinary metals, with the chlorides of potassium and sodium and the nitrates of their oxides, and with chloride of mercury. A more sensible but still very moderate osmose is exhibited

* Op. cit., p. 89. † Phil. Trans., 1855., 177.

by the stronger mineral acids, such as sulphuric and phosphoric, and by sulphate of potash, which are again succeeded by salts of potassa or soda, which possess a decided acid or alkaline reaction, such as binoxalate of potassa, phosphate of soda, or the carbonates of potassa and soda. The highly osmotic substances were found to act with more advantage in small proportions, producing in fact the largest osmose in the proportion of one-quarter of one per cent. dissolved. Lime and alumina were always found in the solution after osmose, and the corrosion of the septum appeared to be a necessary condition of the floor. Septa of other materials, such as pure carbonate of lime, gypsum, compressed charcoal, and tanners' sole leather, although not deficient in porosity, gave no osmose, apparently because they were not acted on by the saline solutions. Similar results to those obtained from the porous clay septa were found in using animal membrane.

"Osmose appears to play an important part in the functions of life. We have seen that it was peculiarly excited by diluted saline solutions, such as the animal and the vegetable juices are, and that the acid or alkaline property which these juices possess is another favourable condition for their action on membrane. The natural excitation of osmose in the membranes or cell-walls dividing such solutions seems therefore almost inevitable.

"In osmose there is also a remarkably direct substitution of one of the great forces of nature by its equivalent in another force, the conversion, namely, of chemical action into mechanical force. Viewed in this light, the osmotic injection of fluids may, perhaps, supply the deficient link which intervenes between chemical decomposition and muscular movement. The ascent of sap in plants appears to depend upon a similar conversion of chemicals, or at least molecular action into mechanical force. The juices of plants are constantly permeating the coatings of the superficial vessels in the leaves and other organs; and these evaporating into the air, a fresh portion of liquid is then absorbed by the membrane and evaporates; and thus a regular upward current is established, by which the sap is transferred from the roots to the highest part of the tree. In a similar manner the evaporation constantly taking place from

the skin and the lungs of animals, causes a continual flow of the animal juices from the interior toward the surface."*

Increased Action of the Battery by Heat, (p. 361.)—This is generally explained on the electro-chemical theory by the fact that heat augments chemical affinity. The action of this liquid on the positive plate being thus quickened, more electricity is developed, *cæteris paribus*. It is obvious that as heat and electricity are so manifestly correlative if not essentially identical, that the explanations amount in the end to the same.

Relations of Heat and Electricity, (p. 401.)—The general facts in regard to these may be thus condensed :—

1. Development of electricity by heat. Certain crystals, when heated, develope electricity. This was first noticed in the tourmaline, but has since been observed in the Brazilian topaz, silicate of zinc, oxinite, boracite, rhodizite, scolazite, titanite, prehnite, mesolite, quartz and certain artificial crystals. Harvey has shown that there exists a remarkable relation between the form of the crystal and its pyro-electrical properties; that all such crystals are irregular in form, that is, that the corresponding parts opposed to each other are not alike in the number, the disposition and the form of their faces; the summit which has the most faces gives positive electricity by cooling. All pyro-electric crystals have for their polar faces a form which is due to the combination of an holohedral with an hemihedral form.† This development of electricity is analogous to that noticed during the cleavage of many minerals and other crystalline substances, as zinc, sugar, &c. The heat causes a separation of the planes of cleavage of the crystal. (Becquerel.)‡

If two dissimilar metals or two pieces of the same metal in different molecular condition be heated at a point of junction or contact, electricity is developed, which flows from the point of junction to that metal which is the poorer conductor. Other solids besides the metals, and even fluids, give rise to this species of electricity.

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* Graham, op. cit., p. 750.

† De la Rive, Traité d'Electricité, t. ii. p. 470; Paris, 1856.

‡ Ann. de Chim. et de Phys., t. xxxvii. pp. 5, 355.

The order in which the metals stand in regard to this power is wholly unlike the voltaic series, and appears related to no other known property of these elements. The rank of the principal metals in the thermo-electric series is as follows, beginning with the most positive: bismuth, mercury, platinum, tin, lead, gold, silver, zinc, iron, antimony. When the junction of any pair of these is heated, the current passes from the more positive to the more negative, thus bismuth and antimony will form the most powerful combination.

2. Development of heat by electricity. This is seen in the voltaic arch, where the temperature is the highest attainable by artificial means. The development of heat in wires carrying the electrical currents has been carefully studied, and the following law is the result of the labours of numerous experimenters.

When a voltaic current traverses an homogeneous wire, the quantity of heat in an unit of time is proportional to the resistance which the wire offers to the passage of the current, multiplied by the square of the intensity (quantity?) of the current.*

When the current does not traverse an homogeneous conductor, we have first the heat due to the resistance of the conductor, and secondly heat due to the passage of electricity between two dissimilar bodies, or the converse of the thermo-electric pile. Frankenheim,† who has carefully investigated this subject, finds that the elevation of temperature of a thermo-electric union upon the passage of the current through it is directly as the intensity (quantity?) of the current, and not to the square of this intensity, as in the case of the resistance of an homogeneous conductor. It will thus be seen that in any thermo-electric arrangement, the electricity developed by change of temperature and the temperature produced by the same electrical current, are equivalent. By reversing the current, cold is produced at the junction of the positive with the negative member of the thermo-electric series.

Relations of Heat and Magnetism, (p. 409.)—Heat produces magnetic phenomena indirectly by means of circulating thermo-electrical currents. It is indeed generally believed that the magnetism

* De la Rive, op. cit., p. 177.

† Ann. der Physik., t. xci.; De la Rive, op. cit., p. 522.

of the earth itself depends upon the circulation around the globe of thermo-electrical currents. Heat applied to a magnet, however, impairs or destroys its powers. A magnetic bar plunged into boiling water, loses a part of its magnetism, which loss increases with each subsequent immersion. A magnetic bar when raised to a red heat, not only loses its magnetism, but is as incapable of receiving magnetism from any of the usual processes of magnetization as would be any substance the most incapable of magnetism.

Magnetism may develope heat. 1. By inducing waves of electricity in a wire (magneto-electricity) as happens when a magnet is introduced into an helix of covered wire. In order to render these continuous it is necessary to give motion to the magnet. 2. Magnetization of a bar raises its temperature and alters its conducting power for heat. 3. Magnetic force by producing motion may develope heat.

Correlation of the Physical Forces.—This subject has, since the publication of the first edition of this work, attracted much attention, although no very definite result can be said as yet to have been attained. The leading facts bearing upon this subject may be thus very generally stated. A full discussion of the subject will be found in Mr. Grove's work, " Correlation of Physical Forces," 3d ed., London, 1855.

1. *Motion*, when arrested, developes heat, as in ordinary friction; conversely, heat developes motion, as in expansion and change of state. Heat and motion have been shown by the experiments of Joule, Rankin and others to be equivalent, (p. 427.) Motion arrested, also causes electrical excitement, as in the ordinary frictional electricity; it seems also to develope chemical affinity, as in Bertholet's process for the synthetic formation of the alcohols from the hydrocarbons, by prolonged agitation of the latter with mercury and sulphuric acid.*

2. Heat developes light as in incandescence, chemical action as in ordinary ignition. Its relations to electricity and magnetism have already been alluded to, (p. 438–9.)

3. Light causes chemical change, and this developes both heat and

* Chemical Gazette, Feb. 1855.

electricity, and secondarily, magnetism and motion. The magnetization of needles by the violet ray of the spectrum is not universally admitted. The greatest illuminating power resides in the yellow part of the spectrum. The heating power is almost entirely absent in the violet and the blue, where the chemical agency is the greatest, and it is greatest beyond the red, and extends a considerable distance where no illuminating or chemical power is ordinarily manifest.

4. Electricity causes motion, developes light, heat, magnetism, chemical affinity and even the nerve force. These points are all discussed fully in the body of the work.

5. Magnetism may develope motion, heat and electricity, (p. 440.)

6. Chemical combination developes heat and electricity, and secondarily, motion, light and magnetism.

As to the ultimate nature of these forces, or this force in its various modifications, we know nothing. Some physicists, as Grove, Clausius, Krönig and Joule contend that the phenomena can be explained upon the supposition of mere molecular change or vibrations in bodies. Others refer the phenomena of light and heat to undulations in an ether as described in the text. The undulatory theory of light alone explains satisfactorily many of its phenomena, and may be considered as having received experimental demonstration by the exceedingly delicate experiments of Foucault,* Fizeau, Breguet† and Nobert.‡ The refraction, decomposition, and polarization, both plane and circular, of heat, are phenomena which can only be well explained upon the hypothesis of undulations in an etherial fluid. This, however, does not necessarily conflict with the material theory so strongly advocated by the author.

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* Methode général pour mesurer la vitesse de la lumière dans l'air et les milieux transparents, par M. L. Foucault; Comptes Rendus, May 6th, 1850.

† Sur la vitesse comparative de la lumière dans l'air et dans l'eau, par MM. H. Fizeau and L. Breguet; ibid., June 17, 1850.

‡ Journ. Frank. Instit., 3d ser. xxvi. 181.

ANALYTICAL INDEX.

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